New Realities

Energy Security in the 2010s and Implications for the U.S. Military

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This compendium of executive summaries is based on presentations delivered at a conference by the same name that was organized by SSI, hosted by the Reserve Officers Association in Washington, DC, and funded through the generous support of the U.S. Army War College Foundation. The conference – free and open to the public – was held on 19-20 November 2013, and featured experts from the policymaking community, academia, think tanks, the private sector, and the military services. These individuals gathered together to address the rapidly changing global energy supply situation, the social, political, and economic challenges facing consumer states, and the subsequent implications for the United States generally and for the U.S. military specifically.

New Realities: Energy Security in the 2010s and Implications for the U.S. Military
Conference Executive Summaries
Edited by John R. Deni
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Cover Photos:

Upper Left: Iraq - A U.S. Army convoy of fuel trucks lines up to fill the fuel pits at the Sahl Sinjar Air Field in Ninawa province, Iraq, Nov. 8, 2008. Photo By: Lance Cpl. Kelly R. Chase.

Upper Right: Tan Tan, Morocco -- Maj. Sean M. Sadlier (left) of the U.S. Marine Corps Expeditionary Energy Office explains the solar power element of the Expeditionary Forward Operating Base concept to Col. Anthony Fernandez during the testing phase of this sustainable energy initiative here May 19. The ExFOB is designed primarily for use by small Marine Corps units at forward operating bases in Afghanistan. Fernandez, a Marine Corps Reservist with a combined 28 years in the Corps, is the African Lion 2010 task force commander here. Photo By: Maj. Paul Greenberg.

Lower Left: A two-megawatt solar panel array at Fort Carson, Colorado, produces enough power for 540 homes, and is one example of the kinds of tools installations can use to achieve Net Zero energy usage. Photo By: U.S. Army.

Lower Right: Forward Operating Base Waza K'wah, Paktika, Afghanistan - Soldiers from Task Force Currahee, 4th Brigade, 101st Airborne Division, recover bundles of fuel that were air delivered to Forward Operating Base Waza K'wah in the Paktika province of Afghanistan via a C-17 Globemaster III. The fuel was delivered to help sustain members of Task Force Currahee whose only means of re-supply is through air delivery. Photo By: Master Sgt. Adrian Cadiz.

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The Arab Uprisings and MENA Energy Producers: Heavy Costs and Ephemeral Benefits

John Calabrese

The Middle East's hydrocarbon resources play a vital role in global energy markets and will continue to do so for many years to come. Meanwhile, the oil and gas sector has been, and is likely to remain of central importance to Middle Eastern countries themselves, whether or not they are major producers-exporters.

Looking at the direct and indirect losses sustained by three countries which, three

years after the Arab Spring protests began, are still experiencing political turmoil and/or conflict – Egypt, Libya, and Syria – and two countries which appear to have benefited from the region-wide upheaval, several things are clear. First, the effects of the Arab Spring on the Middle East and North Africa (MENA) region's energy sector vary greatly by country. Second, there are no clear "winners" and "losers", nor are all of the setbacks and bottlenecks directly attributable to the Arab Spring. Third, on balance the Arab Spring's effects on MENA producers have not substantially jeopardized U.S. energy security – at least not yet.

The target set, timing and frequency of attacks, and level of physical damage inflicted on the region's production, refining, and transport infrastructure has varied widely across the region.

Furthermore, there are a host of factors other than, or in addition to sabotage, that have been responsible for the disruption of energy production and/or exports, including the imposition of sanctions, the seizure of energy installations, and offline maintenance.

These disruptions – wherever they have occurred and whatever their causes – have undermined the ability of producers to meet export commitments and fulfill rapidly rising domestic consumption requirements; worsened their fiscal situations by depressing export earnings and increasing domestic public expenditures; impeded their ability to maintain and/or expand production capacity; further delayed fuel subsidy reforms; and spurred intra-regional energy realignments.

At the same time, the Arab Spring uprisings have been a major factor sustaining high oil prices. This has, in turn, fueled Gross Domestic Product (GDP) growth in Saudi Arabia, the other Gulf Cooperation Council (GCC) countries, and Iraq. This financial windfall has enabled Saudi Arabia, in particular, not just to contain domestic political pressure but to conduct a much more assertive regional foreign policy – sustaining Sunni allies and supporting proxies. However, a number of risks and costs offset such gains, including the spillover effects of the conflict in Syria, the question of whether and for how long such high levels of expenditure can be sustained, the strain placed on intra-regional relationships, and the possibility of "blowback."

Shale technology and renewable energy provide the United States with the opportunity to further reduce its reliance on imported oil. However, even before the Arab Spring and the shale revolution, the United States had not been dependent on the Gulf for the physical supply of oil. Rather, it depended on the Gulf for price stability – it still does, and will continue to do so. Hence, a strong U.S. commitment to Gulf security will remain essential to oil market stability for the foreseeable future. Neither the Arab Spring nor the promise of "energy independence" appears to have eroded Washington's willingness to fulfill that commitment or the GCC countries' need for it.

The United States was spared the worst case of a post-Arab Spring "price shock" partly as the result of its own soaring production, coupled with the record-high production levels achieved by Saudi Arabia, Kuwait, the United Arab Emirates (UAE), and Qatar. These same supply-side factors afforded the United States the strategic flexibility needed to push for the tightening of sanctions on Iran.

Nevertheless, there are a number of "over the horizon" risks and uncertainties that could have implications for American security policy and hence the U.S. military, including the possible spread of unrest to or within the GCC sub-region, whether Iraq can overcome the political and other challenges that imperil the resurgence of its energy sector, when and under what circumstances Iranian supplies fully return to the market, and the policy choices that China and other major Asian energy consumers adopt in order to ensure that their needs are met.

Russia's Evolving Energy Sector

Theresa Sabonis-Helf

Source: ITAR-TASS

Oil and changes in oil markets are more significant to the Russian economy than natural gas, but gas is more significant in terms of energy security vulnerabilities. The European focus on Russian natural gas arises from individual states' high levels of dependency on Russia, but also from the fact that natural gas is the single largest component of European energy demand – and Russia has the largest reserves in the world. Gas remains a regional, rather than a global market, as less than 33 percent of gas is moved in the sea lanes. The remainder is moved in pipelines, which means long-term commitments to suppliers and supply lines.

Source: RIA Novosti

Gas is likely to retain regional characteristics through 2035. Europe has two opposite fears about Russian energy behavior. The first is that Russia will continue and intensify the pattern seen in the previous decade, of manipulation of energy supply for political reasons. The second fear is

that Russia will pursue incompetent policies at home that reduce its ability to supply European gas into the medium term future. At the present time, the latter is a greater danger, and is exacerbated by new European policies that seek (in part) to address the first danger.

In both oil and gas, Russia is coming to the end of a set of advantages that allowed it to reap abnormal profits. Infrastructure is in need of recapitalization, and fields are declining (four fifths of upstream capital spending is focused on slowing the decline of older fields). These factors, together with domestic energy subsidies, a requirement to prioritize supply for the domestic market, and a high federal reliance on revenues from oil, leave Russian energy undercapitalized even as new pipelines are being built and old fields are declining. Into this set of considerable Russian challenges, Europe is attempting to implement the Third Energy Package, a set of policies that will force disaggregation of supply, transit, and distribution of gas. The policies were designed to enhance competition and transparency. However, the new policies reduce Russia's perceived security of markets, have caused significant tensions between Russia and the EU, and make the problem of recapitalization of the gas sector even more problematic.

Source: Associated Press

Impact of Political Instability on Latin American Sources

David Mares

Latin America was once a major energy provider to world markets and has the potential to become a major exporter of oil and natural gas in the next decade. Latin American energy resources could help further diversify world energy markets away from the turbulent Middle East, contribute to world economic growth by stabilizing and lowering international energy prices, and help mitigate climate change by supporting the turn to cleaner natural gas. Hence the impact of Latin American energy supplies on the United States is largely indirect – namely, via global energy markets and geopolitics.

But translating that international potential into reality requires significant investments in exploration and production, the development of efficient and effective energy markets at home, and a significantly improved distribution of rents associated with hydrocarbon production within Latin American societies, not just between Latin American governments and public and private international oil and gas companies. These are significant challenges, and of the four major Latin American energy producers (Venezuela, Mexico, Argentina, and Brazil) only in Brazil do they appear likely to be successfully addressed.

If Latin American countries are able to make the necessary investments and overcomes the potential challenges, they may be able to tap into an array of promising energy resources. For example, new discoveries of non-conventional sources – such as heavy oil, ultra-deep water deposits, and shale deposits – could increase the region's share of global oil and gas production by 50 percent by 2020, for a total close to 20 percent. Hydropower also represents a potentially significant growth opportunity. Latin America is second only to Scandinavia in terms of hydropower potential.

Latin American countries are also becoming increasingly interested in non-conventional renewables such as bio-mass, solar, and wind. The region is a leading innovator in bio-mass and a significant promoter of these non-conventional sources.

Finally, Latin America is also home to some of the most important sources of critical elements necessary for renewables and other technologies. For instance, Bolivia has the world's most significant deposits of Lithium, while Chile and Argentina are among the main producers globally.

Latin American countries are likely to face significant hurdles in achieving production goals and leveraging these potential resources. Interestingly though, guerrillas and criminal organizations are

not the major challenge for Latin American supply. Instead, a host of other issues will comprise the region's greatest challenges.

First, Latin America lacks the investment capital and human capital to develop these resources and will need to attract them from outside the region. Second, the environment is an increasingly salient issue in Latin America, but most countries have not created a transparent and credible regulatory structure to govern exploitation of natural resources. This makes social disruption to production more likely and increases risks to investors. Third, Latin American governments generally have little credibility in enforcing property rights, whether those are contracts with private companies or the nationally- and internationally-recognized rights of indigenous communities to their cultures and environment.

For most countries, energy security should mean the efficient use of energy, not simply cheap energy to be used inefficiently. However, Latin American governments have a particularly difficult time selling this point at home, in part because the national markets for electricity and natural gas are significantly limited geographically. Additionally, national oil companies have privileged places in most countries for exploration and production[1], but they tend to have to invest their resources in the subsidization of energy at home. One of the practical implications of this is that the pace of exploration and production is slowing in most Latin American countries.

Most often discussions about the distribution of rents associated with natural resources focuses on the division between government and private companies. But governments have been unable to distribute their share to the citizens in ways that promote sustainable national development. When citizens protest the lack of development, governments try to get a greater share of rents from companies, even to the point at which companies cut back on investments. A more effective and efficient distribution of the rents already captured by governments would serve everyone better.

In sum, Latin American countries face many of the same energy security challenges as countries elsewhere, especially in terms of managing trade-offs among competing goals. Political change in many countries across the region has to affect the debates regarding trade-offs, but Latin American countries must modernize their political systems in terms of transparency, accountability, and citizen empowerment – together, these will form the most effective antidote to radical movements on both the political left and right that wait in the wings.

[1] Colombia and Peru are partial exceptions.

The Shale Revolution and the New Geopolitics of Energy

Robert Manning

The combination of computer-aided horizontal drilling and hydraulic fracturing (known as "fracking") technology has enormously boosted both U.S. production and reserves of tight oil and gas, most of it since 2007-8. The United States has already become the world's largest producer of oil and gas hydrocarbons, is projected to surpass Saudi Arabia as the world's top oil producer by 2017, and is expected to become a net exporter by 2030.[2] There are currently ample natural gas reserves to meet current U.S. demand for 100 years. Moreover, estimates of recoverable shale gas and shale/tight oil are continuing to be revised upwards.

It is worth noting that shale technology continues to improve, with recent developments cutting required amounts of water in half, improving knowledge of shale composition, and increasing the production of shale gas and tight oil.[3] The shale revolution has turned the debate on the future of oil on its head: the long running argument about whether or not we have reached "peak oil" is over. Now the issue is whether or not we are approaching "peak demand."

There are several implications of all of this for the future of geopolitics and U.S. foreign policy. First, the center of gravity of world energy markets is shifting from the Persian Gulf to the Western Hemisphere (for example, the United States, Canada, Mexico, and Brazil).[4] Moreover, the bulk of U.S. imports are from the Western Hemisphere, with only about 10 percent coming from the Persian Gulf.

Second, shale gas and tight oil have radically shifted global energy markets and redrawn the global energy map 40 years after the Arab oil embargo. Globally, the shale revolution has potentially repositioned the United States vis-à-vis the Middle East and Asia, putting the United States in a position to challenge OPEC (Organization of Petroleum Exporting Countries) control of oil markets. Additionally, the unconventional fossil fuel revolution will probably lead to surprise developments impacting major oil and gas producers such as Iran, other Persian Gulf countries, and Russia.

Third, domestically the shale revolution has strengthened the U.S. economy, making it more globally competitive. This has dramatically shifted the outlook for U.S. energy security and enhanced America's comprehensive national power. In turn, this has had a broad foreign policy impact. This shift in the U.S. energy situation and its bolstering of national power come at a moment when American

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[2] Elisabeth Rosenthal, "US to World's Top Oil Producer in 5 Years, Report Says," *The New York Times*, November 12, 2012.

[3] See Oilprice.com, "New Fracking Technology to Bring Huge Supplies of Oil and Gas to the Market," January 16, 2012 available at oilprice.com/Energy/Natural-Gas/New-Fracking-Technology-to-Bring-Huge-Supplies-of-Oil-and-Gas-to-the-Market.html.

[4] See EIA, "Energy in Brief," Department of Energy, May 10, 2013, available at www.eia.gov/energy_in_brief/article/foreign_oil_dependence.cfm.

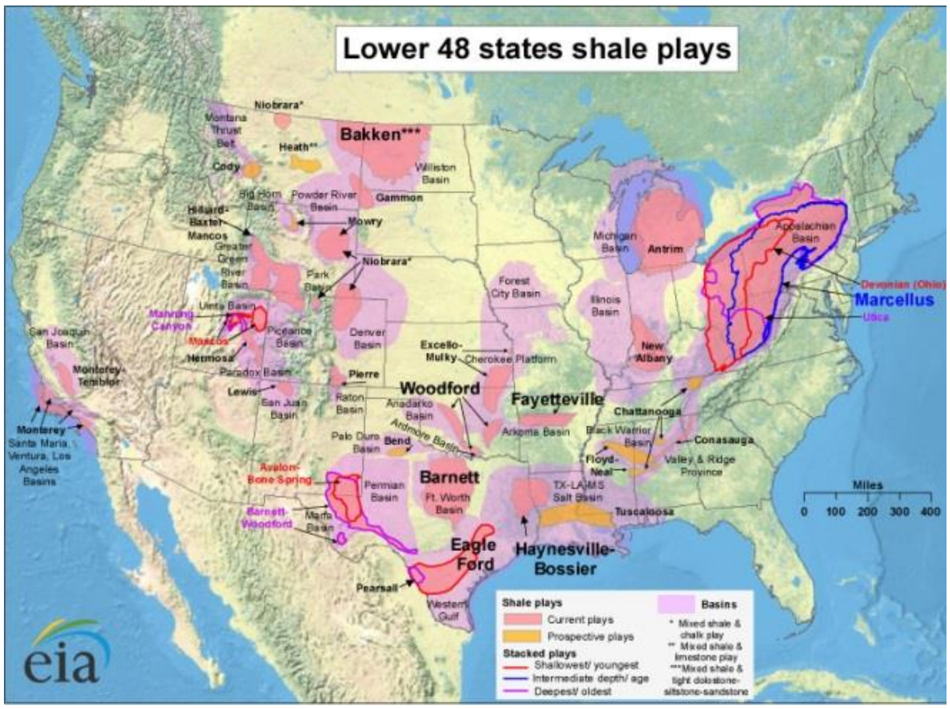
public opinion is reeling from military actions in the Middle East.

While it is and will remain a global oil market, more than two thirds of Middle East oil is exported to East Asia. Essentially, this amounts to a great degree of free-riding by those East Asian countries on the sea lane security provided by the U.S. military. Over time, this is likely to cause many in the United States to raise burden-sharing questions.

The prospect of liquefied natural gas (LNG) exports is now being debated in Congress. For some 20 countries with which the United States has a free trade agreement, such as with South Korea, LNG exports are included in the terms of those agreements. Concerns in some quarters about the impact of exports on the domestic price of gas are overblown.

Energy exports would bolster the U.S. position in Asia. Japan, South Korea, and Taiwan are major gas importers, and China is also becoming a major importer. America's ability to bolster Asian allies' energy security would reinforce perceptions of U.S. reliability. Meanwhile, Russia and Iran – the leading gas producers with the largest conventional reserves – would be big losers.

Another likely challenge will be a greater Chinese role in the Middle East. The Chinese are increasingly dependent on Persian Gulf oil, and are likely to become bigger players in the region. This could be a test of the direction of the U.S.-China relationship.



Source: Energy Information Administration

Finally, two things to watch for as potential political fallout from the shale revolution are closer China-Russia cooperation, as China expands energy ties to Russia to reduce its dependence on the Middle East, and also possible Russia-OPEC cooperation.

The Security Risks and Rewards of Renewable Energies

Karen Smith Stegen

The security rewards of renewable energies are manifold and far outweigh the security risks. However, risks do exist. Policy makers should be both aware of these risks and proactive about addressing them.

In general, the more domestically-sourced renewable energies replace imported hydrocarbons, the greater the security rewards, as renewables will ameliorate the security vulnerabilities caused by imports. Over the past decades, for example, the United States has gone to extraordinary lengths to protect hydrocarbon exporters and sea lanes in order to ensure a steady flow of hydrocarbons to the global economy and thereby prevent the economic damage caused by oil price volatility. Were renewables sufficiently deployed, they could decouple economic prosperity from hydrocarbons, which would endow the United States with greater leeway in its international affairs. Other potential rewards, for the United States or other countries, include diversifying the national energy mix, reducing a country's vulnerability to political manipulation, easing water shortage tensions through desalination (for example, with heat produced via concentrated solar power technology), and increasing regional independence from centralized authoritarian regimes (which, in turn, strengthens prospects for democratization).

The risks vary according to the technologies and energy sectors under discussion. For the transportation sector, there are two methods for deploying renewable energies. First, biofuels can replace conventional fuels in combustion engines. For domestically-sourced biofuels, the disruption risks are similar to those of other crops, such as from poor weather, but also include new risks such as competition from other industries (food, fibers, chemicals) and, for second generation biofuels, reliance on demand for the primary crop. Imported biofuels pose the same risks as imported hydrocarbons.

Second, electric motors can replace combustion motors; the risks associated therein are the same as for several of the main renewable energy technologies (RETs)—such as wind power or photovoltaics (PV)—used in electric power generation. Wind turbines, PV cells, and many other RETs rely on materials subject to current or future availability challenges. In 2011, the U.S. Department of Energy (DOE) assessed the criticality of the materials used in RETs and classified five of them (dysprosium, europium, neodymium, terbium, and yttrium) at the most "critical" level in both the short (0-5 years) and medium (5-15 years) terms. For the transportation sector, as well as for electricity generation, dysprosium and neodymium are critical.

Both of these materials are rare earth elements (REEs): dysprosium is a heavy REE used in wind turbines and e-vehicle motors, and neodymium is a light REE used in the same applications as dysprosium as well as in e-vehicle batteries. China supplies over 90 percent of world consumption of both. Since global demand is expected to dramatically increase, output from new mines in other parts of the world is not expected to alleviate shortages.

Each mineral deposit is unique in its composition, necessitating that both the mining and processing technologies are "custom built," which can require decades. Moreover, both mining and processing are costly and pose environmental challenges. Thus, whereas many countries may have reserves, only some have mining operations and even fewer possess refining capacity. In short, China's capacity in REE processing is so substantial it would take years for other

countries to emulate it. In addition to new mines, other measures for overcoming REE shortages include recycling and developing substitutes, but neither of these approaches has thus far produced fruitful results for dysprosium or neodymium. Subsea mining of deep marine minerals may also offer a new source, but it is decades away from realization.

For many years, China was considered a reliable REE supplier, but problems have emerged. The Chinese government has recently shown concern over the pollution caused by its REE industry and has attempted, for environmental and other reasons, such as rogue production and smuggling, to gain greater control. Meanwhile, Chinese domestic demand for REE is soaring. Starting in 2009, China has annually imposed export quota reductions, not only to protect domestic supply but also, as Chinese officials have admitted, to encourage the development of end-use industries within China. In 2010, the global REE industry was worth $1.3 billion, but end-use industries were worth $4.8 trillion.

The export reductions resulted in skyrocketing prices (some increased by 850 percent) and worldwide concern. In September 2010, these worries were exacerbated when China halted REE deliveries to Japan to exert political pressure. The combination of political manipulation and quota reductions has spurred anxiety in importing countries, resulting in the promulgation of new legislation by governments and the intensification of the search for alternatives by industries. The EU, for example, has begun stockpiling certain minerals, and, in October 2013, the "Critical Minerals Policy Act of 2013" was proposed in the U.S. Senate. The higher prices have also stimulated the re-opening of mines, such as the REE Mountain Pass mine in California, and plans for new excavations in other parts of the world. These operations, however, would be imperiled if China took steps to lower global REE prices—a tactic that is not inconceivable.

Although the danger of shortages in critical materials is relevant for future expansion of renewable energies, they would not result in energy disruptions. However, shortages would pose significant problems for U.S. manufacturers of RETs and impede the ability of the United States to capture the security rewards. In addition to the specific rewards mentioned above, greater global deployment of renewable energies will eventually—not just 'potentially'—re-draw the world map of geopolitical power. Just as with hydrocarbons, geopolitical power will be derived from geography and natural resource endowments. For example, in the era of coal, the countries that were first to harness coal power continue to benefit from being the first industrializers; in the oil era, the industrialized oil-rich countries still count among the world's major powers. If the hydrocarbon era wanes, power and influence will be gained by those countries with renewable technologies and/or raw renewable resources that attain energy independence and export dominance (the "new winners"). The losers will be the countries that lag behind, still bound to hydrocarbon supplies and infrastructure.

The goal of every government should be to secure the foundations for future stability and prosperity. In terms of energy, this means the development of industries and infrastructure that will allow countries to reap the advantages of renewable energies. Policy makers should avoid allowing path dependencies and lock-ins to hydrocarbons to be perpetuated, particularly at the expense of renewables. Hydrocarbon-rich countries, such as the United States, may be particularly challenged to achieve a balance. One immediate recommendation would be to support the rare earth and other critical materials industries in the United States through national laboratories, research funding support, and the passage of supportive legislation.

Africa and American Energy Interests

Ian Taylor

According to the Energy Information Administration (EIA), in 2010, 16 of the 54 countries in Africa were exporters of oil: Nigeria, Angola, Libya, Algeria, Sudan, South Sudan, Equatorial Guinea, the Republic of the Congo, Gabon, Chad, Egypt, Tunisia, Cameroon, Ivory Coast, the Democratic Republic of the Condo, and Mauritania. Africa's proven oil reserves have grown by 120 percent in the past 30 years – from 57 billion barrels in 1980 to 124 billion barrels in 2012. Of note, only four of Africa's oil producers are members of the Organization of Petroleum Exporting Countries (OPEC) – Algeria, Angola, Libya and Nigeria. Although it is estimated that at least another 100 billion barrels are offshore Africa waiting to be discovered, this is likely to be expensive and inconveniently located.

Equally, Africa's proven reserves of natural gas have grown by 140 percent from 210 trillion cubic feet (tcf) in 1980 to 509 tcf in 2012. Recent further discoveries of sizable natural gas reserves in Tanzania and Mozambique point to significant upward potential for these figures.

Many predicted that the United States would acquire even larger amounts of oil from African producers, particularly as U.S. national interests demanded that there be a diversification away from sourcing energy from the Middle East. For a few years, Africa was seen as the "new frontier" for American energy interests and for a time, this was right – from 2002, the United States drastically increased its imports from established producers in Africa, most notably Nigeria, Angola, and Algeria, and also crafted relationships with new producers like Equatorial Guinea and Chad. As diversification away from the Middle East for energy became a central strategic priority, several African nations seemed poised to become important suppliers. However, these hopes were tempered somewhat by the generally insecure investment climate, poor governance, and corruption that characterized much of oil-producing Africa. Additionally, increasing violence in countries such as Nigeria and the rise of terrorism across the Sahel (and into Nigeria and Cameroon) became more of a concern.

The international energy landscape began to change most dramatically though starting in 2010, as companies unlocked tight oil reserves in the United States through hydraulic fracturing and horizontal drilling technologies. Interestingly, this coincided with increasingly pessimistic predictions regarding the long-term supply of energy from key African partners of the United States, with many observers and analysts predicting that after 2015, most current oil-producing African countries would witness a decline in production.

Tight oil and shale gas is likely to radically change the dynamics of U.S. strategic thinking around energy and particularly with regard to Africa. Already, the United States has fallen from being Angola's top oil customer to its third, and Nigeria is exporting 67 percent less oil to the United States than it was at its peak. Even if tight oil production in the United States only

reaches the EIA's lower projections (1.23 million barrels per day by 2035), imports from Africa will continue to decline. This combined with long-term decline in affordable and accessible energy in Africa means that U.S. security concerns in Africa vis-à-vis energy supplies will decline. But other issues will likely develop.

The new U.S. oil glut and resulting suppressed demand for African oil could cause a fall in prices to $70-90 per barrel by 2020 from current levels of $90-$120 per barrel. In fragile states highly dependent upon oil revenue, a price collapse could engender far-reaching economic instability. Nigeria, already plagued by Boko Haram and continuous tensions in the Niger Delta could be seriously affected. Similarly Chad, already vulnerable to the spread of Al Qaeda in the Sahel, may pose as a future area of instability.

So, whilst energy security will be less of a reason for any U.S. military presence in Africa, broader American interests will remain. The fight against global terrorist extremism will continue and the Sahel and the Horn of Africa will likely remain geographic spaces where U.S. involvement is inevitable. Central Africa remains bedeviled by open conflict, both in the eastern Democratic Republic of the Congo and more recently in the Central African Republic. Although neither are intrinsic to a narrow reading of American interests, humanitarian concerns will stimulate some form of American response, although unlikely to be similar to recent U.S. activity against the Lord's Resistance Army in nearby Uganda. Even if the U.S. Africa Command is subsumed back into another organizational set-up, the U.S. military will remain engaged in Africa in some form. Indeed, now that the hyperbole of a "New Scramble for Africa" is likely to be diminished somewhat by the energy revolutions in North America and elsewhere, a more clear-eyed perspective on what the U.S. military is capable of—and just what it should be doing—in Africa, is greatly enhanced. This is actually good news for the military's public relations endeavors and, more importantly, for its strategic planners.

Source: CIA

Does Nuclear Have a Future?

Jane Nakano

Nuclear energy will continue to expand despite the Fukushima disaster. At the beginning of 2011, there were roughly 440 nuclear reactors around the world, generating 370 gigawatts of electricity (GWe), providing 14 percent of the global electricity consumption. Nuclear energy, together with renewable energy, is forecast by the International Energy Agency to be the world's fastest-growing source of energy. Forecast capacity in 2030 and 2050—under low and high scenarios—are higher than today, according to the International Atomic Energy Agency.

Source: U.S. Nuclear Regulatory Commission

However, the capacity expansion is at a slower rate, except in a handful of countries. The share of nuclear energy in the global electricity generation in 2030 and 2050 is forecast to be considerably smaller than today.

Most reactor construction and planned expansion will be in growing economies. Among these, China leads the pack – indeed, 40 percent of global commercial nuclear industry construction is in China today. Meanwhile, Russia plans to increase the nuclear share in power generation from 16.5 percent today to 25 percent by 2030. Elsewhere, there is rising interest among those without nuclear power generation experience or capacity today, especially in the Middle East and Southeast Asia.

Despite this growth and the potential it represents for the American nuclear industry, current global nuclear industry conditions amount to a strong headwind for the viability of the U.S. nuclear industry. Several factors are contributing to this situation. First among them is the rise of new suppliers—with robust domestic demand to back them up. For example, in 2009, South Korea made a very competitive bid to supply four nuclear power plants to the United Arab Emirates (UAE). Additionally, China is striving to incorporate U.S. and French designs, and to market its own advanced nuclear power reactors, including so-called Generation III reactors.

The second major factor shaping the global nuclear power industry is creative export marketing models. For example,

Russia has sought to use a Buy-Own-Operate model in Turkey, while South Korea has pursued this same model in the UAE. To some degree, these creative export marketing models are a result of the fact that the new entrants lack capacities like nuclear reactor operation, fuel enrichment, and spent fuel management (e.g., disposal or reprocessing). Unfortunately for American nuclear companies, the United States has neither a back-end solution – as seen in its policy of "no reprocessing" or a permanent repository solution – nor a strong operational component to offer to the new entrants.

A third important factor is the distinction between sovereign versus market-based approaches. Many countries have one dominant reactor manufacturer and operator. The United States and Japan are exceptions to this. The sovereign model is beneficial in at least two respects – it permits effective advocacy by the head of state and it often amounts to a long-term commitment and hence offers greater geopolitical value. This last point is particularly important, since nuclear reactor deals are hardly ever purely commercial.

Meanwhile, nuclear energy faces mixed prospects in the United States. On the one hand, there are several positive signs in the last couple of years, including President Obama's timely support for "safe nuclear" post-Fukushima. Additionally, in early summer 2011, the Nuclear Regulatory Commission (NRC) concluded there was no imminent risk from continued nuclear power plant operation and licensing activities and that events similar to the Fukushima accident were very unlikely in the United States.

The following year, in early 2012, the NRC issued a combined construction and operation license for two advanced pressurized water reactors each in Georgia and South Carolina. Also, the U.S. Department of Energy (DOE) announced its support for the commercialization of small modular reactors by 2022. In March 2012, DOE announced two public-private partnerships to develop deployment plans for small modular reactor technologies over the next five to ten years.

On the other hand though, the U.S. nuclear industry faces several challenges. The problem of spent nuclear fuel management remains foremost among them, as the Yucca Mountain licensing battle continues. Additionally, low natural gas prices have led to several premature retirement decisions. For example, the firm Excelon recently decided to retire the Oyster Creek nuclear power plant, even though it was licensed to operate until 2019.

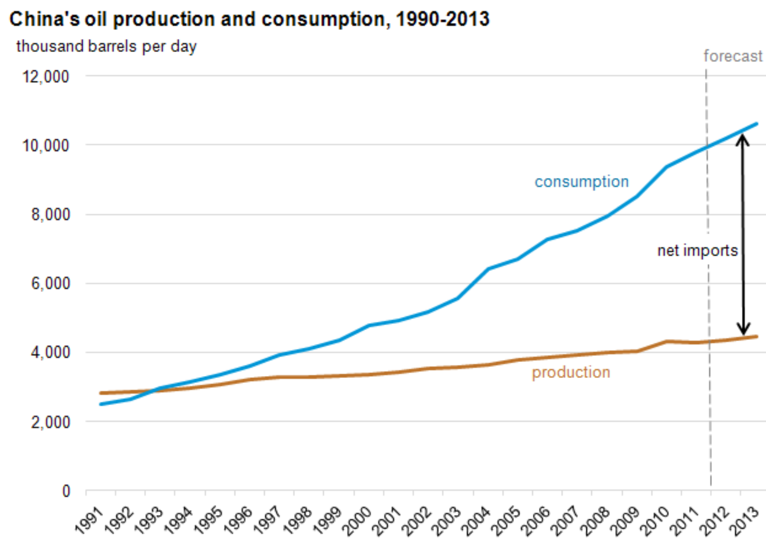
All of this has implications for U.S. national security. For instance, some argue there is a correlation between the competitiveness of the U.S. nuclear industry (in terms of manufacturing and export) and Washington's ability to set the agenda and lead efforts in the area of nuclear nonproliferation. Likewise, there may be a correlation between the U.S. nuclear industry's struggle and the future of nuclear expertise within the U.S. military.

China's Burgeoning Demand and its Quest for Resources

Michal Meidan

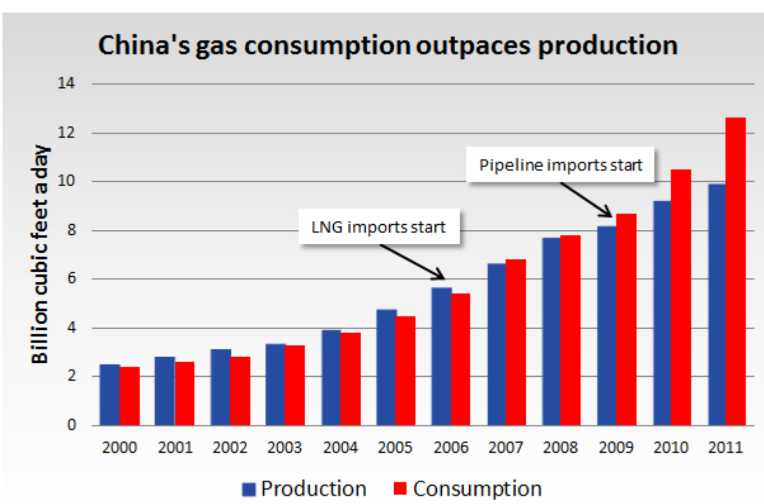
China's energy profile is changing rapidly. After years of breakneck economic growth and ravenous appetite for natural resources, the Chinese government has committed to putting China on a more sustainable development path. Beijing has introduced energy efficiency goals and policy measures aimed at reducing China's carbon footprint by increasing the share of non-fossil fuels to 15 percent of the Chinese energy mix by 2020 and raising the share of gas in the country's energy mix from roughly 5 percent in 2010 to roughly 12 percent in 2020.

But even though renewable energy and nuclear technology will gradually offset demand for coal, China's continued dependence on oil and rising demand for gas—that it will be incapable of supplying wholly from domestic sources—will sustain a high dependence on imported resources. With China's domestic oil production stagnating, the International Energy Agency (IEA) expects its import dependence ratio to reach 80 percent in 2030.



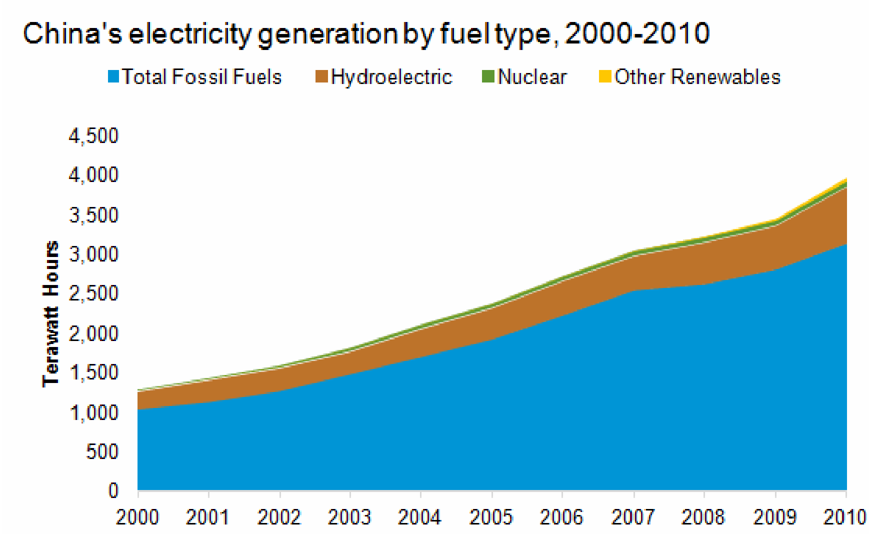
Source: Energy Information Administration

Beijing has over the past two decades made efforts to diversify its sources of imported oil, but it has only managed to tinker at the margins with its heavy reliance on the Middle East and Africa. China remains dependent on six countries for over half of its oil supplies: Saudi Arabia, Angola, Iran, Russia, Oman, and Sudan. And as demand for imported oil and gas will continue to grow, supply security will remain a prominent feature of China's energy strategy and its foreign policy calculus.



Source: Energy Information Administration

China's reluctance to rely solely on imports has led to heavy investments overseas in oil and gas resources, ranging from Sudan to Canada, through Iran and Iraq. Government support for these investments has benefitted China's commercial actors that have sought to become globally competitive energy producers and traders. Yet this has done little to enhance the country's supply security: Chinese traders behave according to market dictates for the most part and sell the resources they produce to the highest bidder.



Source: Energy Information Administration

Aware of the numerous vulnerabilities it is exposed to, Beijing is trying to diversify not only its supply sources but also its supply routes. While the military has been promoting the need to secure maritime transportation as a means to build its naval capacity, Chinese decision makers have also sought to build cross border pipelines through Myanmar, Central Asia, and Russia in a bid to reduce oil flows through the Straits of Malacca.

For all its attempts to purchase assets, "lock in" resources, reduce reliance on maritime transports, and secure sea lanes of transportation, no strategy – as Beijing and its companies are learning – is infallible. The reality remains that much of the oil and gas that is vital to China's economic growth will continue to be produced in volatile countries, traded on international markets, and flow through sea lanes that ultimately pass through the Straits of Malacca.

The sum of these diversification efforts is a growing global footprint. Yet China has neither the intention nor the capacity to safeguard its interests worldwide. Moreover, China is not ready to assume the United States' role as provider of public goods such as freedom of navigation in international waters, or to secure the stability of producer countries. Beijing's preference therefore will remain to free-ride on indirect U.S. security guarantees. With the limits of this preference becoming increasingly palpable, China will begin to experiment with a model of reluctant and narrowly-focused participation in third countries. This presages an era of rising coordination, but also friction, with the United States.

New Trade Routes, New Conflicts?

Michael Klare

International competition for control over vital sources of energy has been a source of conflict throughout human history. Conflict has arisen from struggles over both the major reserves of energy resources and the supply routes used to transport energy from supplying to consumer countries. Protecting such routes has, in fact, been a long-standing mission of U.S. military forces, especially in the greater Middle East. It appears, moreover, that the protection of energy supply routes will continue to play an important role in the strategic planning of the major energy-importing nations.

The strategic importance of international energy supply routes derives from the vital importance of energy to modern industrial economies and the fact that many of the world's major reservoirs of oil (and other key sources of energy) are located at some remove from the major energy-consuming nations and so must be carried to consuming nations via an extended, often vulnerable network of delivery systems – oil and gas pipelines, seaborne commerce, electrical transmission lines, and so on.

By their very nature, these international supply systems are vulnerable to blockage or disruption: they are long, relatively fragile, and traverse a world with many foci of conflict. Much of the world's traded oil, for example, is carried by unarmed tankers across the Persian Gulf and through the Strait of Hormuz – a narrow oil "chokepoint" lined on one side by Iranian missile batteries and naval facilities. Pipelines, shipping routes, and transmission lines are also vulnerable to attack from terrorists, insurgents, and pirates.

Because of these supply routes' vital nature and vulnerability to attack, their protection has long been viewed by importing states as a matter of national security. For the United States, this perception first arose during World War II, when President Franklin D. Roosevelt forged an alliance with Saudi Arabia aimed at ensuring unimpeded access to the Kingdom's massive oil reserves. To ensure the safety of the sea routes used to transport Saudi oil to the United States and its allies, Roosevelt laid the groundwork for a permanent American military presence in the Persian Gulf area.

Ever since the Roosevelt administration, U.S. efforts to ensure the safety of imported energy have largely focused on protecting the flow of oil from Saudi Arabia to international markets. This remains one of the principal missions of the U.S. Central Command (CENTCOM), established in 1983 in accordance with the "Carter Doctrine," which states that the safe flow of Persian Gulf oil is a vital U.S. national interest. But while the Gulf remains the major focus of U.S. efforts to ensure the safe delivery of oil, American leaders have also extended such operations to other areas, including the Caspian Sea region and West Africa.

Many of the initiatives undertaken by American leaders since 1945 to ensure the safety of energy supply lines remain in effect today. But the global energy security equation is now experiencing dramatic change. Among the most significant changes are:

(1) A shift in the center of gravity of world oil consumption from the older industrialized nations of the Organization for Economic Cooperation and

Development (OECD) to the developing nations of Asia, especially China and India.

(2) A shift in import dependence from existing reserves of oil and gas to newly-developed deposits in "frontier" regions, such as Siberia, Central Asia, the Arctic, and deep-offshore areas.

(3) A shift in the geological sources of fossil energy from readily accessible "conventional" supplies to less accessible "unconventional" fuels, such as Canadian tar sands, Venezuelan extra-heavy crude, and hydrocarbons derived from shale formations.

There is no question that these shifts will result in alterations to the world's energy supply systems. The question thus arises: To what extent (if any) will these changes generate new sources of conflict that may subsequently involve the application of U.S. military power? It is too early to provide a definitive answer to this question, but it is possible to identify several problematic developments:

(1) China, India, and Japan are placing increased reliance on military means to ensure the safety of their seaborne energy trade in the Indian and Pacific Oceans. China, for example, is expanding its deep-sea naval capabilities and acquiring experience in distant sea operations. India is also expanding its naval capabilities, and has adopted a new naval strategy focused on the protection of maritime trade routes in the Indian Ocean. Japan – worried about China's naval buildup – is enhancing its own military capabilities. These, and other such endeavors, are generating fresh tensions among these countries (and their neighbors), leading to an increased risk of confrontation and crisis in the Asia-Pacific region.

(2) Russia, with the largest known oil and gas reserves in the Arctic region, is enhancing its capacity to defend its Arctic energy reserves and associated trade routes. This includes the formation of a new Arctic combat group and the establishment of additional bases along Russia's northern rim. Canada and Norway – worried by the Russian military buildup – are taking comparable steps. Canada, for example, has announced plans to build a new fleet of ice-hardened patrol ships, while Norway has moved its combined military headquarters to Bodo, above the Arctic Circle.

(3) China, concerned about the safety of the pipelines it is building to transport oil and gas from Kazakhstan and Turkmenistan, is enhancing its ability to conduct military operations in Central Asia (largely under the auspices of the Shanghai Cooperation Organization). Russia, equally concerned over the safety of oil and gas pipelines in Central Asia (many of which are connected to the Russian oil and gas pipeline network), is also bolstering its military capabilities in the area.

Given these developments, it is safe to conclude that the establishment of new energy supply routes is generating new threats to international peace and stability. Whether or not these tensions will escalate into something more serious cannot be foreseen, but they are certainly contributing to an expansion of military capabilities in areas of potential friction and conflict.

For the U.S. military, this implies a possible reallocation of forces to ensure the safety of the new supply routes and/or greater cooperation with other states to achieve this objective. It also suggests a need for greater international cooperation to reduce the risk of unintended escalation of local crises and disputes. Finally, it raises the question of whether increased reliance on renewable sources of energy would serve U.S. interests by reducing American reliance on imported supplies of energy.

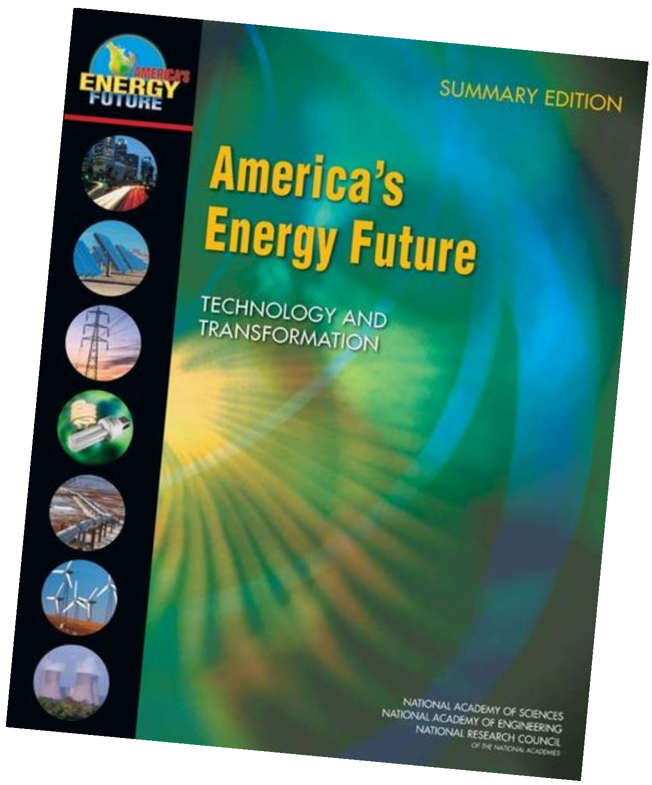
Prospects for Energy Efficiency

Pramod Khargonekar

Driven by global population increase (from 7 billion to 9 billion in 2050), economic growth and societal needs in the developing nations, and continued needs of the industrialized countries, demand for energy is expected to grow significantly in the coming decades. While estimates vary and are inherently uncertain, the International Energy Agency (IEA) estimates that by 2035, primary energy demand will grow roughly 30-35 percent with most of the growth coming from the developing countries. As we confront the challenges in meeting this increased demand, energy efficiency holds enormous potential.

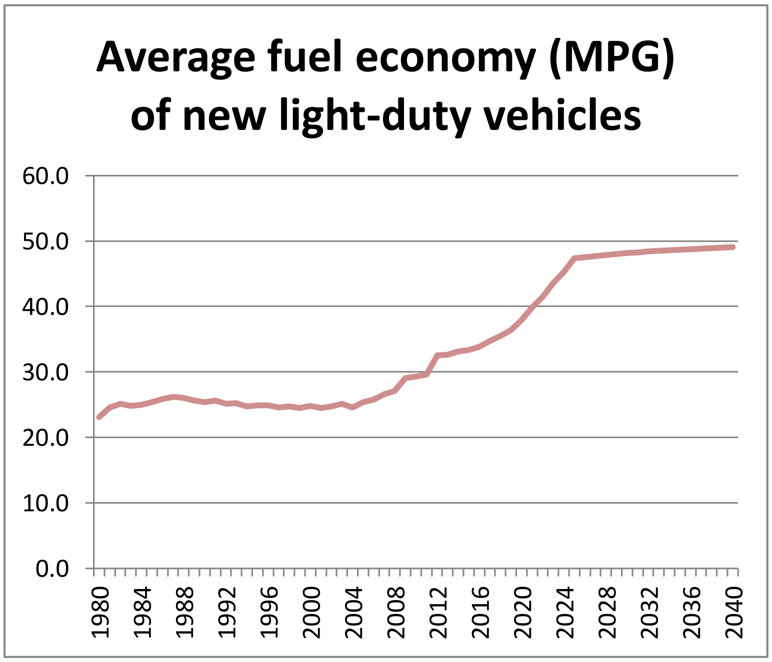
Just in the United States, data from the Energy Information Administration (EIA) suggest that less than 37 percent of primary energy goes toward useful energy services. Many studies have been conducted on estimating the gains from energy efficiency based on technological and economic feasibility. The 2009 report on energy efficiency from the National Academies (specifically, the National Academy of Sciences, the National Academy of Engineering, and the National Research Council) entitled "America's Energy Future," estimates the potential for cost-effective annual energy savings in the United States by 2030 to be between 30 (conservative) and 35 percent (optimistic). The largest contribution (more than half) to these savings comes from residential and commercial buildings. Transportation sectors and industry sectors account for much of the rest.

The potential for energy savings can only increase with advancements of new technologies for building heating and cooling, lighting, windows, gasoline/diesel engines, hybrid and electric vehicles, refining, and production of metals (aluminum, steel), cement, chemicals, and paper. Beyond these, cross-cutting technologies such as combined heat and power (CHP), high temperature and separations processes, materials (nanocoatings, nanoceramics,



refractory materials, insulation), sensors and process controls, electric motors and drives also offer great promise for energy efficiency gains.

Experience over the last three decades shows that policy tools are critically important for successful adoption of energy efficiency technologies and solutions. ENERGY STAR labeling, appliance efficiency standards, building codes, Corporate Average Fuel Economy (CAFE) vehicle efficiency standards, utility and end-use efficiency programs, CHP initiatives, and so forth are excellent examples of successful policies and programs.



Source: Energy Information Administration. All data after 2011 are estimates.

A report from the California Energy Commission in 2007 suggests that energy efficiency contributed the equivalent of 15 percent of annual electricity usage in California in 2003, providing compelling proof for well-designed policy measures. Globally, the IEA estimates that more than two-thirds of potential gains from energy efficiency remain unrealized.

Despite the compelling case for energy efficiency, investments in energy efficiency are much lower than what can be easily justified on the basis of economic gains. This is the so-called "energy efficiency paradox." There are three types of impediments or barriers to implementation of energy efficiency:

1. Structural
2. Behavioral
3. Availability

Examples include regulatory barriers, upfront capital investments, split or misaligned incentives, fragmented or diffused opportunities, ownership transfer before capturing full benefits, adverse bundling, and a lack of awareness and education. Policy and programs can and should be designed to address these barriers.

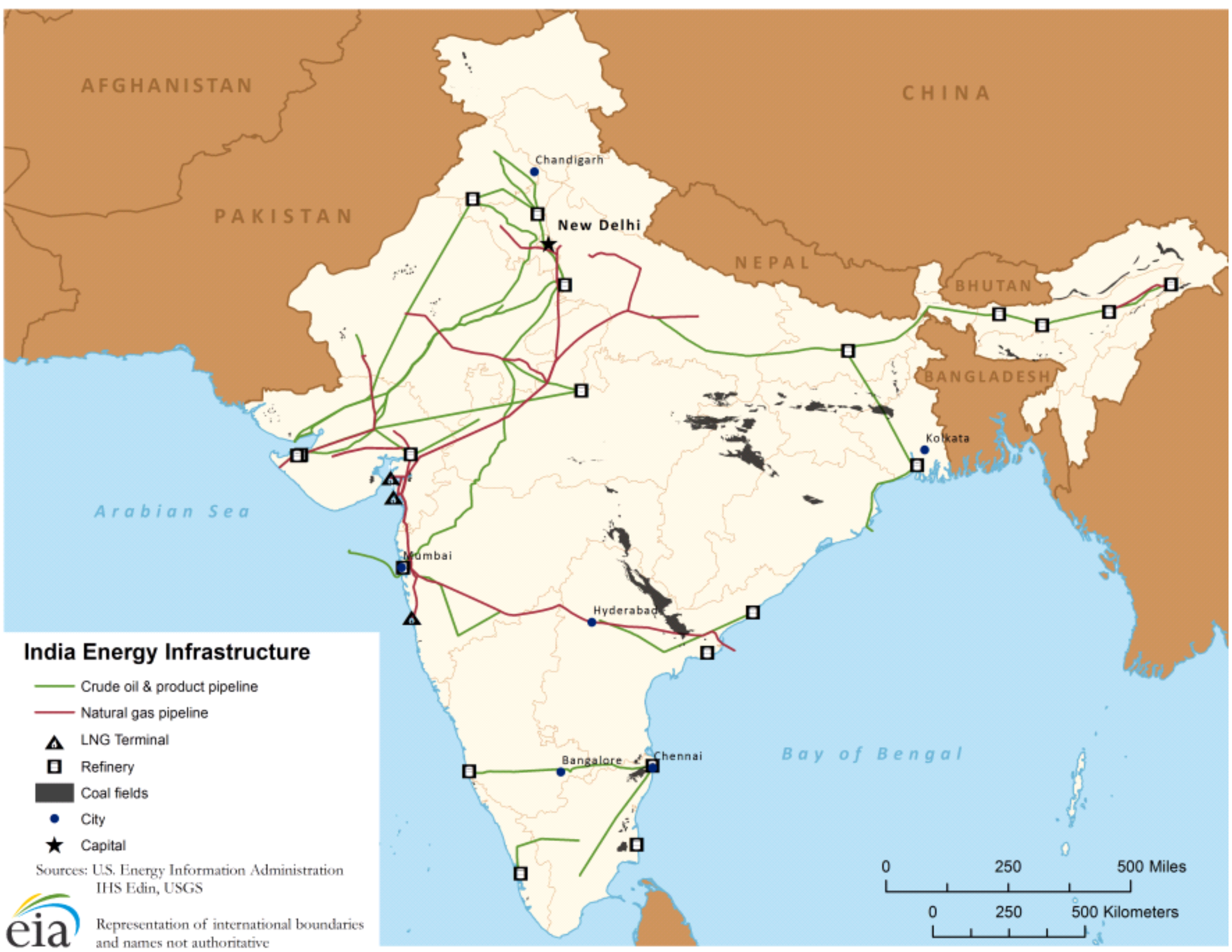
Expected growth in global energy demand will add further pressure on energy security. From this point of view, energy efficiency can be a major tool for energy security as it clearly reduces dependence on unreliable sources of energy, which in turn is likely to have a significant impact on U.S. national security. The above-mentioned 30-35 percent reduction in energy consumption in the United States can easily offset the increase in energy consumption due to population increase and economic growth. But strong, well-designed, and consistent policy and programs will be necessary to realize this potential.

The Changing Calculus of India's Energy Security

Tom Cutler

India's growing demand for energy and its quest for energy security impacts U.S. national interests in a variety of ways. Energy considerations were at the center of the transformation of the Indo-U.S. strategic relationship in 2005 with the announcement of the civil nuclear deal. Since then, cooperation in clean energy has been a driving force in taking the Indo-U.S. energy relationship to a new level. Looking ahead, it appears that Indian concerns about its energy security, including its desire to import U.S. liquefied natural gas (LNG), will come to the forefront as its growing import dependence and America's growing energy self-sufficiency change the calculus of India's energy security. This changing calculus of India's energy security will have important implications for U.S. military planners.

Although slowing, India's annual economic growth rate of around 8 percent in recent years has fueled dramatic increases in its demand for energy. Even though its per capita energy consumption is about only one-third of



Source: Energy Information Administration

the global average, India is now the world's fourth largest energy consumer. India's demand for energy is expected to double over the next 20 years supplied by growing consumption of high-ash coal-fired power and increased imports of oil, natural gas, coal, and uranium. India's import dependence from 2010 to 2035 is projected for each of the primary fossil fuels as follows: coal's dependence doubles from 16 percent to 33 percent, oil jumps from 76 to 92 percent, and gas, mostly LNG, grows from 20 to 36 percent. Given the sheer scale of India's energy needs – it will become the world's most populous nation sometime in the 2020s – it is inevitable that its growing import vulnerability (which is the crux of India's energy security challenge) will have regional and global impacts of military significance.

India's export oriented refinery sector could be a supplier of fuel to U.S. forces deployed in the region. At the same time, India will look to the United States as a strategic source of imported LNG and, to a lesser extent, coal. Meanwhile, India's energy footprint dominates South Asia, where the considerable potential for intra-regional trade in natural gas, hydro-power, and electricity remains unrealized. The precarious state of Pakistan's energy sector represents an unpredictable threat to Indian and U.S. interests, especially if that nation destabilizes under the weight of its energy woes. South Asia has a looming energy crisis and long term energy security will not be achieved without intra-regional cooperation.

Looking outward from South Asia one cannot ignore India's geographic location astride the sea lanes in the Indian Ocean where 70 percent of the world's oil trade, 60 percent of LNG, and 70 percent of coal trade is transported, and where some predict the United States, India, and China will inevitably compete for blue water dominance. Indeed, the most important military implication of India's growing energy needs is its increased reliance upon sea borne trade in energy and uncertainties regarding the future U.S. role as a guarantor of safe passage.

It is in the U.S. interest for India to be energy secure. But India faces many difficult challenges and its leadership will be under increasing pressure to satisfy its growing energy needs. Many of the solutions to India's energy challenges require significant domestic political will. Controversial issues such as the adoption of true market pricing and privatization of key energy para-statals are all subject to the vagaries of India's vibrant democratic process. But as imports rise India can no longer insulate itself from world energy markets and it will need to develop strategic alignments and expand its universe of international cooperation to enhance its energy security. This includes cooperation with the United States and the International Energy Agency (IEA) in regard to the development and use of strategic oil stockpiles and cooperation among major consuming nations in the event of an oil supply crisis.

As an emerging energy supplier and as a key ally of India with a number of proven bilateral mechanisms for energy cooperation already in place, the United States is well positioned to forge even closer civil and military ties to enhance mutual energy security.

Energy Demand and the Developing World

Deborah Gordon

The 2000s generally found energy demand leveling off in developed countries and taking off in the developing world. Between 1970 and 2010, global energy demand doubled and began to shift from the developed to developing regions. The aggregate share of energy consumption in the countries that comprise the Organization for Economic Cooperation and Development (OECD) shrank significantly from 60 percent to 41 percent, off a much larger base. The regions that grew their energy consumption most over the past 40 years include the Middle East, Asia, and Africa.

Future growth trends are expected to continue in this direction, with energy demand expanding faster in the developing world. As the citizens in the developing world become more affluent, modernization and mobility will increase. These trends, in turn, will increase energy consumption more rapidly in developing nations.

According to the International Energy Agency, between 2011 and 2035, world primary energy demand is projected to increase worldwide at an average annual rate of 1.3 percent. The OECD regions are expected to grow more slowly than the non-OECD. While the OECD currently consumes more energy than any other region, starting in 2025, it is anticipated that Asia in its entirety (including China) will demand more energy than the OECD nations combined. The share of energy consumed in the OECD is projected to contract from 40 percent to 32 percent through 2035, continuing a downward trend that began in the latter part of the 20th century. China, India, Brazil, Indonesia, the Middle East, and Africa are among the developing nations that are expected to experience the most rapid growth in energy demand in the years ahead.

Disaggregating demand by energy sources indicates significant changes ahead. Looking out to 2035, non-OECD nations will dominate energy consumption across the board—except for nuclear power. Electricity generation, powered by renewables and natural gas, is projected to increase in the OECD and take off in all developing regions. China will consume more electricity and coal than the entire OECD. Oil, gas, and coal consumption are projected to be comparable. More gas will flow to the developing world than the OECD. The developing world will become more dependent on oil and gas. As they continue to motorize, oil consumption is projected to expand across the board in all developing regions. Nuclear energy is projected to play a relatively small role meeting energy outside the OECD. All of these changes will play out against the backdrop of increasingly dynamic energy markets.

These factors all have implications for U.S. and developing country security. Overall, the developing world is projected to become less energy self-sufficient in the decades to come. The developing countries are planning to invest an estimated $23 trillion (2011 dollars) on energy infrastructure through 2035, nearly twice as much as OECD nations. Oil investments are projected to be

distributed across all developing countries, while gas, coal, and power investments will be centered largely in Asia's developing nations. These infrastructure investments will likely lock in energy consumption patterns through the middle-to-end of the century. Selecting energy investments wisely will be critical, but it will also be difficult. Setting electricity aside, many developing nations have a long history of massive fossil fuel consumption subsidies. In 2011, these subsidies approached $0.5 trillion—the majority in the Middle East, North Africa, and Asia.

Taken together, oil and gas will continue to dominate energy demand into the future. Transportation costs are a relatively minor part of the energy supply chain making fossil fuels easy to move around the globe. A wider array of nations will consume oil and gas resources while a select few will demand coal and nuclear power. As such, oil and gas trade will continue to grow—bolstered by the unconventional resources that are being tapped—and more suppliers will be vying for market share. While increased competition in oil and gas markets could ultimately be beneficial, growing global energy interdependence brings the risk of short-term supply interruptions. Moreover, organizing more market actors could lead to oil and gas price volatility, with associated energy and economic security impacts.

Geographic choke points for oil and gas will not disappear in the future. If anything, they could become even more concerning. Oil will move as crude and petroleum products and natural gas is moved by pipeline over land and increasingly liquefied moved by maritime shipping from continent to continent. By 2035, for example, a significantly increased amount of oil and gas could be moving through the Straits of Malacca and Hormuz.

Strategies that focus on reducing energy demand will not be adequate to ensure security in the future. In a world of growing fossil fuel supply availability, which is increasingly mobile through free trade agreements, reducing domestic energy demand will only facilitate energy movement. Lower energy transaction levels are manageable and can increase global security. At higher levels propelled by energy deficits in several developing nations, however, there are mounting risks of disruption due to economic, political, infrastructure, and environmental sources.

Energy demand in the 2010s and beyond will have significant impacts on the U.S. military. As energy trade continues to globalize, it will take more resources to maintain energy and economic stability throughout the world. Leadership will remain critical. At the same time, America will need to play an increasingly discerning, collaborative, and nuanced role in its dynamic and interdependent energy future.

Hacks on Gas: Energy, Cybersecurity, and Defense

Christopher Bronk

Cybersecurity has grown to be a preeminent concern for the national security organs of the United States government. Within certain circles, one need only say "cyber" to indicate the topic of cybersecurity. It is an area that has become of great interest, but in cybersecurity there is also tremendous ambiguity. How great is the threat to the United States, its overseas interests, the U.S. economy, and its armed forces? Cybersecurity practitioners and experts have some idea, but there is a degree of hyperbole surrounding the issue and some heads in the sand as well.

How cybersecurity issues fit into energy security is a more manageable subject of inquiry, but it is important to consider what is meant by energy security. Writ large, energy security for the United States is the capacity for U.S. consumers, be they individuals, organizations, corporations, or government agencies, to gain access to the energy supplies they need or want. Foreign embargos, tropical cyclonic activity, midstream plant disasters, and military action are all potential threats to energy security for the United States. Energy production in the United States is changing, however.

We cannot consider threats to energy security without accepting the rise of oil and gas production in the United States over the last decade. Computer-aided, horizontally drilled, hydraulically fractured oil and gas drilling has produced a dramatic rise in domestic production, now totaling some 7 million barrels of oil per day and 2.1 million cubic feet of natural gas per month. U.S. production gains provide a degree of security from disruptions in international supply, but it is necessary to acknowledge that oil is traded on a global market, and regional gas markets may increasingly become interlinked over time. Thus a disruption in the Persian Gulf, East Asia, or Africa does not insulate prices paid for oil or even gas in the United States.

In addition to the supply of energy, which also includes other fuels such as coal and nuclear, each with their own environmental and sustainability issues, there are the matters of processing and distribution. This composes the remainder of the energy supply chain, which among other items includes: gas, coal, and nuclear power stations; electricity grids; oil and gas refineries; and pipelines. The United States should be concerned with cybersecurity in energy because as with other areas of the global economy, computing has been widely adopted in the energy sector. For example, supercomputing is a key component to seismic analysis; refineries are increasingly driven by Supervisory Control and Data Acquisition (SCADA) systems; and the U.S. electrical grid has incorporated "smart" elements, including digital sensors, meters, and monitoring systems. The ubiquitous Internet Protocol interconnects many of these computers.

If there were no networked computers in the energy sector, discussion of cybersecurity issues would be moot. But for decades, computation has been deeply incorporated into energy exploration, production, distribution, and consumption, as well as the corporate and managerial activities supporting those activities. Thus, there are cybersecurity issues for energy. While many scenarios posit a massive hack of the electricity system and its catastrophic failure, there are plenty of other more likely and less spectacular energy cybersecurity issues.

In particular, there are three major cyber concerns in the oil and gas sector:

- Theft of core intellectual property;
- Disruption or destruction of physical plant and other points of capital investment; and,

- Compromise of communication by executive decision makers regarding key business decisions.

Recent cybersecurity events indicate that these scenarios are very much within the realm of possibility. The Stuxnet worm (a piece of self-propagating malicious software) was ostensibly aimed at an energy target, the Iranian nuclear enrichment infrastructure. Another worm, Shamoon, spread rapidly across the personal computers of Saudi Aramco at incredible speed, deleting the contents of perhaps as many as 30,000 hard drives and also impacting systems at other companies.

What such cyber-attacks mean to U.S. energy security and the security of energy needed by the Department of Defense (DoD) requires significant thought. At a global level, the United States needd to consider how likely an oil or gas disaster produced or facilitated by cyber means actually is and what can be done to mitigate that threat. For DoD, important questions need to be raised about the security of computer systems employed in the distribution of electricity and fuels from major bases to forward deployed elements in contact with hostile forces. Of particular interest here is the reliance of the services on energy management undertaken via the DoD's Non-classified Internet Protocol Router Network (NIPRNet), which includes connectivity to the public Internet.

In coping with cyber security issues as they pertain to energy security matters, there are several points of consideration:

1. Recognize that cyber incidents like safety or disruption events are not just organizational issues but ones of potential concern across an extensive, interconnected energy supply chain.
2. Develop trusted third party and clearinghouse relationships aimed at developing better cyber intelligence and analysis.
3. Produce and constantly refine models of cyber risk intelligence merging valuation of assets/processes, threats, and reasons for potential compromise.
4. Consider the cybersecurity ramifications as the 'Internet of things' expands to cover more and more infrastructure, including hundreds of millions of energy-related computing devices.
5. Connect the spheres of geopolitics and the technical aspects of cybersecurity to develop holistic models for coping with the cybersecurity problem.

These recommendations represent an initial thrust of activity, but instituting them will require difficult shifts in behavior for government and industry. Additionally, it is worth considering how cyber incidents can play out very quickly. For instance, the compromise of the Associated Press's Twitter feed by the Syrian Electronic Army and its transmission of a bogus tweet regarding an attack on the White House led to trading algorithms employed by participants in the New York Stock Exchange (NYSE) issuing a high volume of sell orders. In less than two minutes, the value of the NYSE fell by roughly $136 billion. The index recovered quickly but there were both winners and losers on the deal. Although the energy industry may not hold a similar sort of vulnerability, we must assume that foreign adversaries including states and transnational actors will target it. Necessary then is deep analysis not only on vulnerability, but also on the resiliency of the energy supply chain to cyber-attack.

Operational Energy as a Stepping Stone Toward National Resilience

Paul E. Roege

Army Operational Energy (OE) concepts are leading the way toward more informed use of energy within the military and beyond. Historically, most energy management discussions, military or civilian, hone in on the single attribute of quantity. The natural consequence is an inevitable focus on consumption and ultimately, performance objectives seeking reduction. In truth, this commodity view of energy is problematic because energy benefits can be quite difficult to relate directly to quantity consumed. For many, the morning and evening commutes are the most energy-intensive activities of the day, yet they produce no direct value. Occupational energy consumption, at least in an office environment, may be characteristically lower and even then, productivity may vary significantly in response to relatively small changes in energy consumption manifested in lighting levels or room temperature. Military operations represent an even greater energy analysis challenge, recognizing for example that transportation and life support often require greater total energy consumption than ground maneuver itself, especially in a dismounted mode.

Energy no longer can be treated simply as a commodity to be minimized. Like information, energy is a multi-attribute entity whose net contribution to capabilities and performance depends upon how it is managed. Operational Energy concepts and analyses have produced a useful model to improve effectiveness in military operations. Specifically, the principle of "energy-informed operations" calls for Soldiers and Army leaders at all levels to manage energy use to achieve the greatest net operational benefit in a given situation. This requires an understanding of how various attributes such as efficiency, energy density and storage capacity factor into mission capabilities and vulnerability. Translated to decisions and behaviors, dismounted Soldiers may selectively operate electronic devices; drivers may adjust vehicle speed; or commanders may specify fuel stockpile levels to balance endurance, timing, and risk exposure. Implementing this energy-informed concept requires substantial individual and organizational understanding of energy principles, effective techniques, and management tools. This new concept has led each of the military services to undertake culture initiatives with heavy emphasis on education and training, but balanced with investments in enabling technologies.

Although focus to date has been on deployed operations, the energy-informed approach to OE applies equally to global operations at all levels – tactical to strategic. This suggests the need to engage operational communities that have not been central to OE efforts, such as space, network, and intelligence operations. This expanding perspective will bring additional challenges. First, many of these operations involve more complex technologies and systems, therefore complicating the challenge of sorting out energy implications and decisions. As with most changes, organizational aspects promise to be the greater challenge. To date, OE principles have been implemented within deployed

operations, which had been exempted from legacy energy management programs. Bringing energy-informed principles to missions conducted from enduring infrastructure will require reconciliation of the multi-attribute energy capability and performance model with existing consumption-based installation management processes.


Source: Claire Heininger, U.S. Army

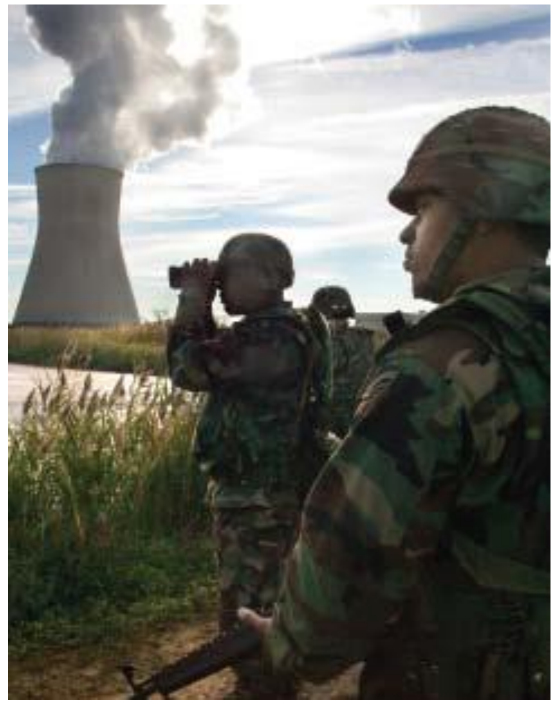
Ultimately, OE offers a prospective platform from which to launch a broader resilience thrust within military communities and beyond. Resilience as a concept offers not only a means to relate energy to outcomes; it also represents a useful model to address uncertainty and change in a dynamic, globalized world. Adoption of resilience principles will require a difficult mental transition from traditional methodologies that seek to quantify and definitively disposition risk, yielding to more fundamental systems analyses and collaborative processes that posture the overall system to perform well under a broad range of conditions. This adjustment inevitably will be uncomfortable for some, but most will quickly recognize that military operations already are not self-reliant; that nearly every essential service depends upon non-military partners. Teaming on energy resilience is simply a next logical step, building upon such existing community partnerships as those in health care and law enforcement. Energy is a key element in U.S. economic success, social order, and national security. Operational Energy and its natural outgrowth of resilience offer important pathways to align each of these concerns through mutually-supporting objectives.

Terrorist Energy Sector Targeting: U.S. Military Implications

Robert J. Bunker

The very nature of terrorist energy sector targeting is problematic because of limited definitions of terrorism that focus on the political intent (input) that are behind the metrics of counting a specific attack as a terrorism incident. Based on these criteria, the number of global terrorist energy sector targeting incidents is fairly moderate; less than 500 over the last 30 years, based on estimated Global Terrorism Database (GTD) incidents.

However, given the increasing blurring of armed non-state groups—with organized crime, terrorist, insurgent, and other attributes—and the fact that organized crime and insurgent attacks on this sector are largely ignored in the metrics, far more energy sector incidents that result in 'terrorist like' outcomes (outputs)—like blown pipelines and armed assaults—exist. As a result, over 500 insurgent attacks on the energy sector in Iraq alone during the allied occupation—which prominently saw U.S. Army involvement—took place between 2005 and 2007, but these were never counted in terrorism databases. In fact, according to the Energy Infrastructure Attack Database (EIAD), since 1980 about 8,000 incidents have taken place globally, making such 'terrorist' incidents relatively common – and 16-times GTD entries.



Source: Tech. Sgt. Mark Olsen

Recommended courses of action for the U.S. Army span the three levels of 'terrorism' energy sector effects. None of these courses of action require Army structural or organizational changes. At the kinetic level, the current Army orientation has strong antiterrorism (AT) and force protection (FP) protocols developed over a decade of operations in the Iraqi and Afghani theaters. As a result, no new courses of action are required for mitigating this level of terrorist activity.

Source: Oak Ridge National Laboratory

At the level of disruptive outcomes to energy production and distribution—derived from attacks on the energy infrastructure as a system (for example, aimed at key nodal points), limited recommendations exist due to the present level of Army critical infrastructure protection (CIP) awareness outside the continental United States. These recommendations focus on the need for additional training centered on analytical

Source: Department of Homeland Security

and physical red teaming to help mitigate key nodal/systems-focused attacks along with the potential for limited troop deployment surges to protect critical infrastructure under imminent threat.

At the actual generation of terror (political nature of the act) level of effects, the recommended course of action is for additional training being provided for public and press information officers. The intent is to further strengthen the U.S. strategic narrative in order to limit the generation of terror and its disruptive bond-relationship targeting effects directed at allied coalitions, host governments, and U.S. and allied citizens.

While overseas terrorist energy sector targeting is in many aspects a 'non-issue' for the U.S. Army, since it is presently well organized, structured, and trained to respond to this form of threat, additional research and study directed at the interrelationship of physical with cyber-based terrorism is warranted. Terrorists may very well benefit from the synergistic and dual-dimensional nature of physical and cyber terrorism, a threat in its own right, applied together at the second level of concern – that is, one which results in physically disruptive outcomes to energy production and distribution.

An Intergovernmental Approach to Energy Security: The Role of NATO

John R. Deni

As early as 2006, and arguably since the 1999 strategic concept, the North Atlantic Treaty Organization (NATO) has recognized that it may have a role to play in energy security. At the 2006 NATO Riga summit, which occurred not long after the first Russia-Ukraine gas dispute, NATO declared its support for a coordinated, international effort to assess risks to energy infrastructures and to promote energy infrastructure security. In April 2008, during the alliance summit in Bucharest, NATO leaders declared their intent to take on energy security in a variety of ways, including by engaging in energy security-related information and intelligence fusion and sharing, by supporting consequence management, and by supporting the protection of critical energy infrastructure.

In 2010, NATO built on the 2008 declaration with a firmer commitment and a formal inclusion of energy security into its strategy, or Strategic Concept. In that document, NATO declared that communication, transport, and transit routes on which energy security depends require greater international efforts to ensure their resilience against attack or disruption. The alliance then resolved to develop the capacity to contribute to energy security, including through protection of critical energy infrastructure and transit areas and lines, cooperation with partners, and consultations among Allies.

However, the alliance has struggled to move beyond the conceptual when it comes to what might be thought of as the traditional energy security sphere. The primary reason for why the alliance has failed to make progress in this traditional energy security realm is because there remain fundamental divisions among member states in terms of attitudes toward energy security. Those that want energy security on the alliance agenda include most of the newer alliance members in Eastern and Central Europe, countries with vivid memories of life under Soviet domination. They are adamantly pro-energy in NATO, and they proved particularly adept at getting energy security onto the agenda at the 2006 Riga summit. Unfortunately, their efforts have yet to result in a long-term, coherent, practical roadmap for what NATO and its member states should do specifically in this issue area.

At the other extreme are several members – including some older alliance members in Western Europe – that remain hostile toward alliance involvement in this issue area. Some in this camp argue that critical energy infrastructure protection is a national responsibility, not a NATO problem; others believe NATO's engagement in energy security unnecessarily militarizes a non-military sphere; and still others believe NATO involvement in this issue area unnecessarily antagonizes Russia.

Despite these disagreements over NATO's involvement in broad energy security issues, the alliance is nevertheless making some limited progress in terms of *operational* energy security. For example, the alliance developed a Smart Energy Team (SENT), which consists of representatives from six NATO allies, including the United States, and two partner nations. This effort, funded by the NATO Science program, is essentially a best

practices experts group whose objective is to look at promising technologies and to formulate standardization agreements. Additionally, NATO established an Energy Center of Excellence in Vilnius, Lithuania. This organization is currently engaged in commissioning several studies on operational energy issues, developing an operational energy concept in conjunction with ACT, and developing training programs on operational energy security.

These two efforts are really the only success stories so far in terms of whether an intergovernmental approach to energy security – as promulgated by and through NATO – might prove successful, and, from a purely parochial viewpoint, beneficial for the U.S. military. The reason for this is largely because they both fit more squarely within NATO's traditional focus – that is, on the operational efficiency and effectiveness of alliance member state military forces.

Whether and how Washington can effectively leverage NATO to promote operational energy security and ultimately its own interests is the subject of ongoing discussion. Certainly, it makes great sense for the U.S. Department of Defense to pursue increased collaboration through NATO on operational energy security for several reasons. First, as seen in several U.S. national security strategies over the last decade, the United States prefers to fight in coalitions. If that continues to be the case, then America will need partners both willing and able to deploy and fight with it. Helping those partners to reduce their operational costs while increasing their operational capacity and combat capability through greater energy efficiency makes it easier for them to participate in coalitions.

Second, although the United States does more than other allies in terms of operational energy security research, development, testing, and procurement, there are indeed prospects for the U.S. military to learn from its allies. British development of intelligent power storage and management systems, Dutch development of photovoltaic solar panels and LED lamps, and German work on hydrogen fuel cell technology all represent potential areas where the United States could stand to learn more about what the allies are developing and producing.

Third, working with and through NATO provides the United States with an echo chamber of sorts – a means of propagating and amplifying best practices and promising technologies. This will become increasingly important in the years ahead, as the alliance will struggle to maintain operational and tactical interoperability in the absence of operations in Afghanistan.

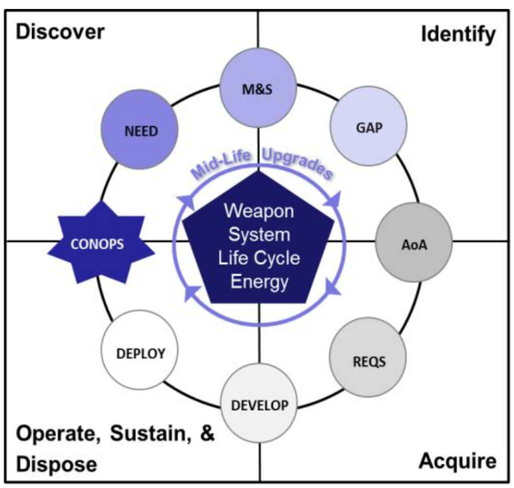
In terms of *how* the United States works with and through NATO, there are two recommendations in particular. First, Washington should focus its operational energy security cooperation within NATO on those allies with larger militaries and larger deployable forces. The allies most interested in contributing to operational energy security efforts are those for which the costs of fuel are a significant deterrent to deploying their forces.

Second, the United States should place increased effort on conducting demonstration events and exercises with NATO allies that include operational energy scenarios, or 'injects', in the language of the military trainer. In sum, an intergovernmental approach to energy security can benefit the U.S. military both now and when Washington needs coalition partners, provided DoD focuses its efforts, remains cognizant of domestic politics, and limits what it seeks to accomplish through NATO.

Operational Energy in Weapon System Life Cycle

Kevin T. Geiss

The utilization of energy in operational environments is driven by three primary considerations: number and type of employed military capabilities and the manner of their operational employment. Weapon system employment decisions comprise the preponderance of operational energy consumption during the prosecution of military campaigns. Future development decisions for Air Force platforms continuously occur, with operational requirements being driven by increased threat, advances in research and development, shifting geopolitical priorities, or existing system limitations providing the impetus to initiate new capability development. The weapon system development cycle can be parsed into four phases, depicted below. In order to successfully integrate energy considerations into the weapon system life cycle, different actions must be taken in each phase.



Source: U.S. Air Force

The U.S. Air Force is committed to providing maximum warfighting capability in Air, Space, and Cyberspace. Energy, a key operational enabler, is often viewed as a logistical concern when delivering military capability. However, in order to optimize the effectiveness and sustainability of warfighting capability, energy must be considered throughout a weapon system's lifecycle. The existing process for weapon system development provides a robust framework readily capable of integrating energy considerations.

In the Discover Phase, strategic policy and directives from the Office of the Secretary of Defense and identified threats from Combatant Commands (CCMDs) determine the need for future concepts of operations (CONOPs) and capabilities. Once developed, these requirements are sent to an Air Force Major Command (MAJCOM) to begin analysis and to determine how to provide the necessary capabilities. If existing systems are suitable, needs are identified and validated through a robust modeling and simulation activity. This phase represents the opportunity for the greatest impact in ultimate operational energy requirements. At this point, it is vital to address how a new capability would interact with the intended system of systems employed throughout the proposed CONOPs. An assessment should consider the impacts of platform contributions on operational energy requirements and the necessary logistical support requirements. Focusing on underlying CONOPs allows for capabilities to be scrutinized prior to need identification.

The Identify Phase further refines the modeling and simulation (M&S) analysis activity to better identify the necessary capabilities, culminating in the development of a capability gap. Once codified, the capability gap is refined, with parameters being developed for the future Analysis of Alternatives (AoA) activity. During AoA, a lead MAJCOM examines the plausible strategies to fulfill the capability gap identified. Next, courses of action are recommended for implementation, with varying levels of capability and associated funding levels. Energy

considerations are driven by the identified needs and previous CONOPs. Doctrinal reviews may identify much more efficient methods of addressing capability gaps and establish new pathways to examine during the alternatives analysis.

The Acquire Phase begins with the selection of a particular course of action, and then formal acquisition commences. Acquisition begins with the definition of Key Performance Parameters (KPPs) and Key System Attributes (KSAs). The development of the Energy KPP (eKPP) represents the first insertion of energy considerations into the current Weapon System acquisition process. The eKPP includes platform and system of system level considerations; both aspects require different analyses in order to effectively comply with broader Defense Department guidance. Currently, the eKPP is only required for major defense acquisition programs; however, all acquisition programs *should* address energy usage. At this stage, the system's operational capabilities dictate baseline energy consumption. Without dramatic changes to underlying CONOPs, energy reductions will require significant additional resources. Therefore, energy considerations are included in the 'tradespace' of operational capabilities. As cost, schedule, and performance concerns are identified, Program Managers make resourcing decisions to ensure capabilities are produced.

In the Operate, Sustain, and Dispose Phase, the developed system is procured. The new capabilities are used to update operational strategies and plans, focusing on future threats and the CCMD's ability to mitigate them. Decisions such as strategic basing, resource prepositioning, and Air Tasking Order construction determine the utilization of operational energy. Continual reevaluation of existing capabilities and threats determine future needs and provide grounds for weapon system improvements. During this phase, reduction in energy consumption is derived from improved employment strategies for weapon systems. In addition, CONOPs for current operations drive the identification process for new capabilities. Understanding existing capabilities is essential to producing a more energy aware Air Force.

Throughout a weapon system's life cycle, modifications may be necessary. Whenever this occurs, a reevaluation of existing systems must occur. Upgrade decisions initiate the development process, with the cycle occurring in earnest once more. This process is intrusive, with declining weapon system availability degrading Air Force operational capability. While energy improvements can occur, energy considerations rarely predicate large scale investment. Energy savings can be an ancillary benefit to capability improvements.

Weapon system development is a necessary activity for the Air Force. These systems are the basis for providing the military capability for the Air Force to fly, fight, and win in Air, Space, and Cyberspace. In order to enable these capabilities, the Air Force must strive to achieve and maintain the strategic energy advantage in all domains. The existing weapon system development process provides the necessary framework to achieve this outcome. However, decisions are currently constrained, ensuring that operational capability considerations supersede all others. Optimization of energy for weapon systems ensures a sustainable and supportable warfighting capability. Therefore, energy considerations should occur at the earliest possible stage, thereby providing the greatest optimization opportunities. Additionally, once deployed, weapon system employment considerations provide the greatest potential for immediate energy savings. Throughout the process, whether identifying new capabilities or utilizing existing systems, energy consequences are driven by military CONOPs and decisions. Understanding the energy impacts of these decisions are essential to better employing and sustaining an effective fighting force.

Operational Energy Security at the Installation Level: The Role of Nuclear Power

Ronald Filadelfo

In section 2845 of the 2010 National Defense Authorization Act (NDAA), Congress tasked the Department of Defense (DoD) to study the feasibility of powering military bases with small modular reactors (SMRs). The belief was that military installations can serve as a test-bed for this technology and perhaps help jump-start an American SMR industry. The resulting feasibility study concluded:

- SMRs could help DoD in terms of energy security for its installations, as well as with various energy and greenhouse gas reduction goals.
- Even if a decision is made to proceed, it will take about 10 years before a SMR could be producing electricity. There are many issues that remain to be resolved, including the effect a nuclear power plant could have on the function of the installation.
- Finally, a SMR could be cost effective for a DoD installation if some other entity picks up the "First of a Kind" (FOAK) costs.

Although these findings suggest that the SMR-military installation concept is worth examining further and perhaps entertaining specific proposals, they do not imply that DoD should immediately pursue a plan to locate a SMR on a military facility. Many criteria need to be met before that can occur, and it remains to be determined if DoD will ever find a location that meets all the criteria. The feasibility study simply concluded – as was its tasking – that this is worth further examination.

Waste disposal is a major issue that remains to be solved before DoD – or the nation as a whole – can make a serious commitment to nuclear power in any form, be it commercial-scale or small modular reactors. Security is sometimes mentioned as a benefit of locating a SMR on a military base. However, nuclear facilities already employ a great deal of security and access control, and although location on a military installation provides some additional security, in reality it is just another "fence line", and not a major consideration.

Source: U.S. Army

Compatibility with installation missions is a major concern for DoD. For example, the Department would need to consider how close a military housing complex should be from a nuclear facility. Similarly, DoD would need to determine

the appropriate standoff distance of a nuclear facility from a military air station, ordnance facilities, or other ranges. Since completion of its feasibility study, DoD has not pursued any SMR projects, although the department has not ruled this out for the future. Meanwhile, the Department of Energy (DoE) is partnering with the Tennessee Valley Authority (TVA) and Babcock & Wilcox mPower, Inc. to undertake a project at the Clinch River site in Oak Ridge, Tennessee. Under this partnership, DoE will pay about half of the design and licensing costs. The objective is to develop a 180 megawatt (MW) facility, which could be operational by 2022. If completed, this would be the nation's first operational small modular reactor. This project is still in its infancy and its successful conclusion is far from certain. For instance, Babcock & Wilcox must still obtain Nuclear Regulatory Commission certification for its reactor design, which it hopes to have by 2016. At that point, the TVA will decide whether it wants to proceed with construction of the site. It is likely DoD will monitor the TVA before moving on its own. Given the planned timeline for the TVA project, this implies that DoD is unlikely to move forward on SMRs for several years, at a minimum, despite the potential benefits for the military specifically and the United States more generally.

Source: Tennessee Valley Authority

Technological State of Play: Smart Grids for Operations and Installations

Kenneth A. Loparo

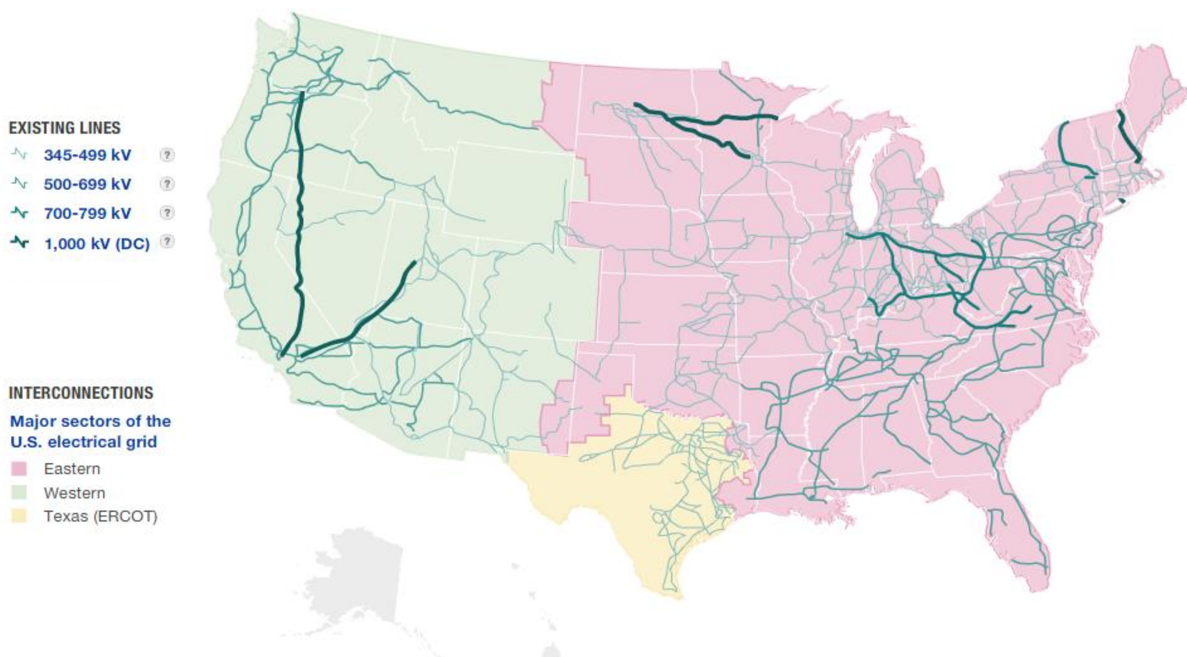
"Smart Grid" refers to the modernization of the electricity grid to improve efficiency and overall operational reliability. A major focus of this effort to date has been on technology development and deployment, such as the deployment of synchrophasors[5] in the high voltage bulk transmission system and smart meters in the distribution network as part of Advanced Metering Infrastructure (AMI). However, meeting key challenges and realizing true opportunities requires a total "systems" approach.

As it exists currently, the U.S. electricity system includes end-to-end operations from supply to demand, including generation (centralized, distributed, renewable), transmission, distribution, storage, and consumption. There are several problems with this system today:

1. The electricity grid is a highly interconnected system that is prone to cascading events through state/structure interactions;

2. The grid is also highly vulnerable due to primary (environmental, equipment malfunctions, loads) and secondary (protection, operator initiated actions) disturbances; and,

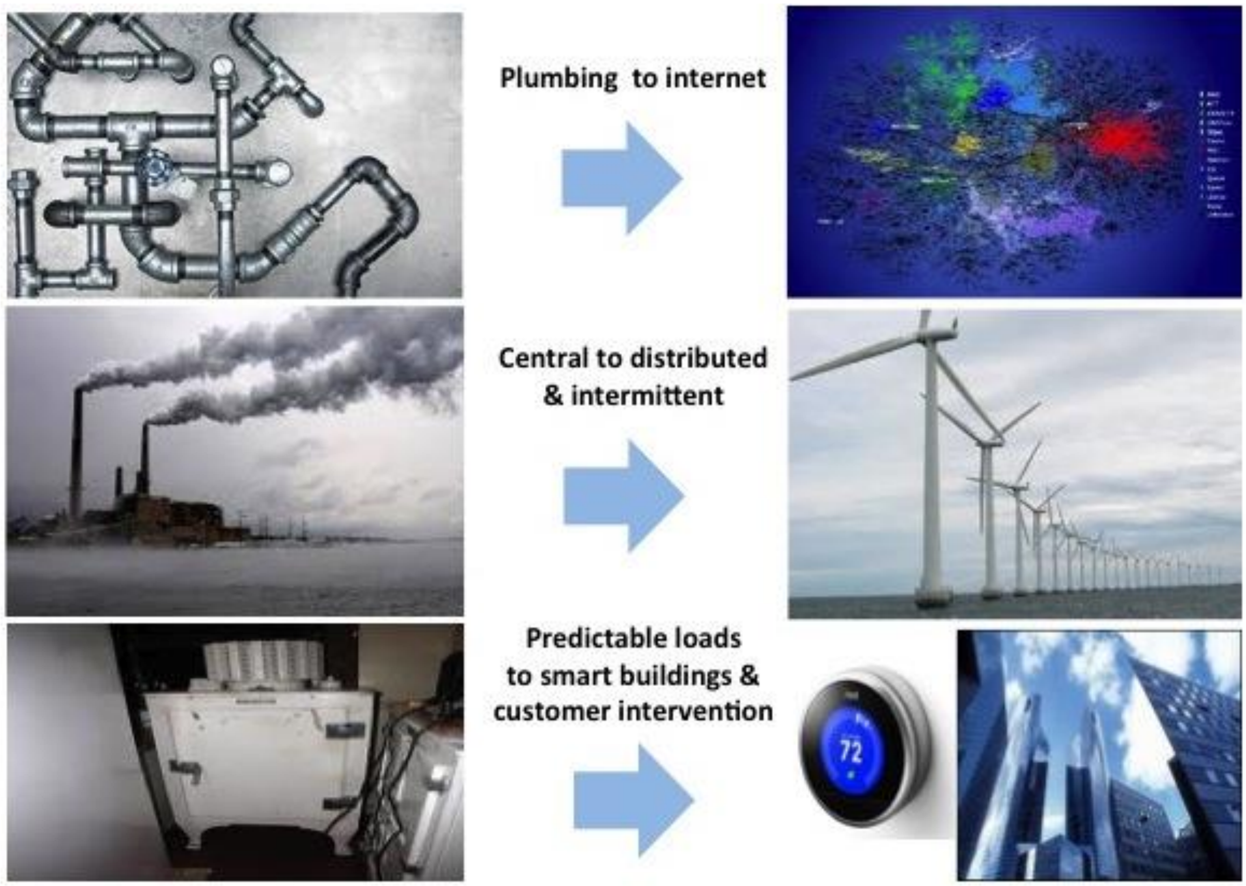
3. There is poor situational awareness across the grid, as well as a lack of controllability.



Source: National Public Radio

[5] A synchrophaser is a device that measures the electrical waves on an electricity grid.

As shown in the figure below, the future electricity system will transition to a cyber-physical system in which integrated sensor, communication, and control networks enable improvements in



Source: Kenneth A. Loparo

situational awareness, operational reliability, stability and security, and efficiency from supply through to demand. These same ideas provide opportunities for military installation energy security. However, if military officials do not properly attend to the cyber-physical aspects, such a system can also increase vulnerability because of the greater reliance on data communications and autonomous system operations. This has potential implications for the military in the context of both homeland security – that is, protecting the U.S. critical infrastructure – as well as the reliability of grid connectivity to military installations.

Overcoming Challenges from the National Electrical Grid

John Dodson

America's transmission system is perhaps the weakest and most vulnerable in the developed world. Thousands of miles of unattended and bare wires with thousands of volts pulsating upon them traverse vast spans of open space, lacking fences or impediments to access in most places. In alternating current (AC) systems, inherently unstable, a failure attracts more current as electrons rush into new paths, and may cascade to a dreaded blackout.

Each U.S. town developed its own utility company as a "natural monopoly," connecting to each other with transmission only with reluctance. But monopoly utilities are best preserved by bottlenecks and lack of connectivity. Today, the Federal Energy Regulatory Commission (FERC) attempts to weave together the grid the United States needs badly but does not have, laboring against the formidable resistance of the 550 or so local utilities. The United States has made remarkable progress toward at least regional integration in the eastern and western portions of country – through so-called Interconnects – with the Energy Reliability Commission of Texas remaining the lone localized holdout.

Nevertheless, significant challenges confront the existing system. Perhaps only the victims of catastrophes like Hurricane Sandy or the widespread wake-up call of the 2003 blackout have even an inkling of the real devastation to the economy and security of this country such events portend. Even fewer are aware of how easily a small group of technically savvy individuals, armed only with chains and aluminum balloons, could bring down the nation's grid for days, if not weeks. If that small group were slightly larger, and spread out nationwide for a synchronized action with explosives against key substations with components that need a year's lead time to build, and the damage is almost unthinkable. It would take months, perhaps a year to fully restore prior conditions and the economy.

To deal with some of these longstanding challenges, over a decade ago, U.S. Army General Paul Kern sought to forge more effective information sharing among Army labs, force innovation within the major defense contractors, and permit private entities to validate their energy-related concepts through projects on Army bases.

Even before the attacks of 9/11, roughly six small, innovative companies with patents, ideas, and high interest were converging on various military bases. Together, they solved Army problems vis-à-vis energy – at the same time, the Army became a laboratory for the grid security solution, which all recognized as one of the two great energy challenges for the Defense Department and the nation.

In 2009, this group of companies seeking to develop solutions to the nation's electric grid security challenge handed over much of their work, as well as their lessons learned, to the Army Energy Initiatives Task Force. One of the critical, original solutions developed over the years was the concept of a municipal or military base-sized microgrid, dubbed a MuniGrid, that would employ solar, wind, combined heat and power (CHP), hydro, and energy storage, with a base load source that might be waste to energy, geothermal, a small modular reactor (SMR), or natural gas, combined with legacy systems that might exist on a given base.

Source: National Institute of Standards and Technology (NIST).

The military MuniGrid would have two parallel electrical systems. The first would be the original existing one, augmented by as much local solar, distributed energy and storage, fuel cells where practical, and smart building systems with improvements in heat and insulation. The second would consist of large new utility-grade energy systems, existing as tenants on the base, which would power the base as a small part of the target 500 megawatt virtual generation plant that the renewable portfolio of available sources would create. The objective would be to achieve a commercially viable enterprise financed with Power Purchase Agreements (PPAs) with regional load centers, as with any new generation system. Military PPA's could provide the basic underpinnings of the financing, and this system would provide true "NetZero Plus" security to first responders, as well as an assured black start capability for the regional electricity grid dispatch authority.

These systems, created on key Army bases initially, and receiving subsidies for the extra expense at those locations requiring higher security (triple redundancy), guarded with the intrinsic physical security of military bases, could become the secure energy nodes for a new organization of the national grid. Comprised of about 17 new Interconnects, this system would not transmit the problems that AC now does throughout the two large eastern and western Interconnects, which leads to blackouts. It would in effect compartmentalize the national grid and allow the true creation of one coherent system, designed along the outline already achieved by FERC, but many times stronger, more predictable and ten times more difficult to break or destroy.

Each new Interconnect would contain at least one military security MuniGrid, which would be operating at a profit that would not require taxpayer support, other than the extant utility costs. The Interconnects would have to be part of a national plan, which could take roughly three years to formulate, and which would be the beginning of the ultimate restructuring that must occur. Stockholders' and ratepayers' interests would need consideration, and achieving success and acceptance at grassroots levels would be a daunting initial challenge.

If done in the name of national security, like the Interstate Highway System, the economic payoff would be transcendent. The increase in national security would be fully as great. It should begin with Army MuniGrids, and new connections between bases through the grid.

Biographical Notes

Dr. Theresa Sabonis-Helf is a Professor of National Security Strategy at the National War College in Washington, DC, where she has taught since 2001. She was previously Energy and Environment Policy Advisor for projects based in Central Asia managed by the Harvard Institute for International Development and the International Resources Group. She has worked as a Visiting Fellow at the U.S. Agency for International Development and as a Policy Analyst for think tanks in the United States and Russia. She has published articles on climate change policies, post-Soviet energy and environmental issues, regional and international energy trade, and the politics of electricity.

Dr. John Calabrese teaches U.S. foreign policy at American University in Washington, DC. He also serves as a Scholar in Residence at the Middle East Institute (MEI) where he directs a project on The Middle East and Asia. He is the Book Review Editor of The Middle East Journal and General Series Editor of MEI Viewpoints. He is the author of *China's Changing Relations with the Middle East* and *Revolutionary Horizons: Iran's Regional Foreign Policy*. He has edited several books and has written numerous articles on the international relations of the Middle East, especially on the cross-regional ties between the Middle East and Asia.

Dr. David Mares holds the Institute of the Americas Chair for Inter-American Affairs at the University of California, San Diego. Dr. Mares has been Professor of the Centro de Estudios Internacionales at El Colegio de Mexico, Fulbright Professor at the Universidad de Chile and Visiting Professor at FLACSO-Ecuador. He is the author or editor of eight books, and his publications have appeared in English, Spanish, French, Portuguese, Italian, and Chinese journals.

Mr. Robert A. Manning is a senior fellow with the Brent Scowcroft Center on International Security at the Atlantic Council. He formerly served as senior strategist, National Counterproliferation Center from 2010-2012, and as director, long-range energy and regional/global affairs, U.S. National Intelligence Council, Strategic Futures Group from 2008-2010. From 2005-2008, he served as a member of the secretary's Policy Planning Staff, Department of State, and from 2001-2005 he was senior counselor, energy, technology and science policy, Department of State.

Dr. Karen Smith Stegen is the KAEFER Professor of Renewable Energy and Environmental Politics at Jacobs University and an associated scholar with the Bremer Energie Institut, both located in Bremen, Germany. Dr. Smith Stegen began her energy career over two decades ago in the international affairs department of a major U.S. energy company. Her recent publications include articles for *Energy Policy* and *Risk Management*, and she is a featured speaker at numerous industry and academic conferences.

Dr. Ian Taylor is Professor in International Relations and African Politics at St. Andrews in Scotland and Chair Professor in the School of International Studies, Renmin University

of China. He is also Professor Extraordinary in Political Science at the University of Stellenbosch, South Africa, an Honorary Professor at the Institute of African Studies, China, and a Visiting Scholar at Mbarara University of Science and Technology, Uganda. Focusing largely on sub-Saharan Africa he has authored seven academic books, edited another eight, and has published over 60 peer-reviewed scholarly articles.

Ms. Jane Nakano is a fellow in the Energy and National Security Program at the Center for Strategic and International Studies (CSIS). Her research focus includes nuclear energy policy and technology trends globally, energy security issues in Asia, and shale gas development in the United States. Prior to joining CSIS in 2010, Ms. Nakano served with the U.S. Department of Energy (DOE) and worked as the lead staff on U.S. energy engagements with China and Japan. She was responsible for coordinating DOE engagement in the U.S.-China Strategic Economic Dialogue, U.S.-China Energy Policy Dialogue, and U.S.-Japan Energy Dialogue.

Dr. Michael Klare is a professor of peace and world security studies, and director of the Program in Peace and World Security Studies (PAWSS) at Hampshire College. He has written widely on U.S. military policy, international peace and security affairs, the global arms trade, and global resource politics. His several books include *The Race for What's Left*, and his articles have appeared in many journals, including *Arms Control Today*, *Bulletin of the Atomic Scientists*, *Current History*, *Foreign Affairs*, *Harper's*, *The Nation*, *Scientific American*, and *Technology Review*.

Dr. Pramod P. Khargonekar is the Eckis Professor of Electrical and Computer Engineering at the University of Florida. In March 2013, he was appointed by the National Science Foundation (NSF) to serve as Assistant Director for the Directorate of Engineering (ENG). In this position, Dr. Khargonekar leads the ENG Directorate with an annual budget of more than $800 million. Dr. Khargonekar's research and teaching interests are centered on theory and applications of systems and control.

Mr. Tom Cutler has nearly 40 years' experience in international energy affairs including a 36-year career at the U.S. Department of Energy (DOE). Most recently, as Director of DOE's Office of European and Asia Pacific Affairs, he played a key role in the launch of a number of new initiatives in Europe and Asia until his retirement from DOE in July 2013. Previously, Mr. Cutler managed DOE energy policy dialogues with a number of countries including Indonesia, India, China, Japan, Korea, Australia, Pakistan, Bangladesh, Norway, and the United Kingdom.

Ms. Deborah Gordon is a senior associate in the Energy and Climate Program at the Carnegie Endowment for International Peace (CEIP), where her research focuses on oil, climate, energy, and transportation issues in the United States, China, and globally. Ms. Gordon has served on National Academy of Sciences committees and the Transportation Research Board Energy Committee, lectured widely and given keynote speeches, and been featured on radio, TV, and in print media. Her recent book, *Two Billion Cars* (with Daniel Sperling) provides a fact-based case and roadmap for navigating the biggest global

environmental challenge of this century—cars and oil.

Dr. Christopher Bronk is the Baker Institute fellow in information technology policy at Rice University. He holds additional appointments at the Baker Institute Center for Energy Studies, Rice University's Department of Computer Science and the University of Toronto's Munk School of Global Affairs. His research focuses on cyber geopolitics with additional work in innovation, knowledge management, international politics, and policy related to intelligence and international security. In addition to significant work in the cybersecurity area, he has published on a broad range of issues, including broadband and Wi-Fi policy, information technology sector energy consumption, intelligence and information sharing issues, U.S.-Mexico policy, and digital diplomacy.

U.S. Army Colonel (ret.) Paul Roege is a lifelong energy aficionado who focuses on the role of energy in building resilience at the community and regional levels. He recently spent four years on active military duty to establish the Army's operational energy concepts and strategies, seeking to use energy most effectively toward operational outcomes. He substantially influenced the Army's and other military energy strategies, including adoption of a concept for "Energy-Informed Operations." He also guided Army energy research and development thrusts toward more integrated, network foci, and advocated for the emergent shift toward resilience as an overarching concept for energy security.

Dr. Robert J. Bunker is a Distinguished Visiting Professor and Minerva Chair at the Strategic Studies Institute, U.S. Army War College. He is also Adjunct Faculty, School of Politics and Economics, Claremont Graduate University. Dr. Bunker has delivered over 200 presentations, including papers and training, to military, law enforcement, and academic and policy audiences, including U.S. congressional testimony. He has over 200 publications ranging from edited books and booklets to reports, chapters, articles/essays, response guidance, subject bibliographies, and encyclopedia entries in academic, policy, military, and law enforcement venues.

Dr. John R. Deni is a Research Professor of Joint, Interagency, Intergovernmental, and Multinational (JIIM) Security Studies at the Strategic Studies Institute, U.S. Army War College. He previously worked for eight years as a political advisor for senior U.S. military commanders in Europe. While working for the U.S. military in Europe, Dr. Deni was also an adjunct lecturer at Heidelberg University's Institute for Political Science – he taught graduate and undergraduate courses on U.S. foreign and security policy, NATO, European security, and alliance theory and practice. He is the author most recently of the book *Alliance Management and Maintenance: Restructuring NATO for the 21st Century*, as well as several journal articles.

Dr. Kevin T. Geiss is the Deputy Assistant Secretary of the Air Force for Energy. In that role, he is responsible for providing oversight and direction for all matters pertaining to the formulation, review, and execution of plans, policies, programs, and budgets for the effective and efficient use of energy to support the global Air Force mission. Previously, Dr. Geiss served as the U.S. Army's Program

Director for Energy Security, where he was responsible for the development and implementation of the Army Energy Security strategy.

Dr. Ronald Filadelfo serves as Leader of the Environment and Energy Research Group at the Center for Naval Analyses (CNA). The group's current research focus includes the relationship between climate change and national security, and installation and operational energy issues for the military. In 2007, Dr. Filadelfo led the analysis and writing team that supported the CNA Military Advisory Board study of the effects of climate change on national security. He was recently a member of a National Academy of Sciences Naval Studies Board that examined the implications of climate change for U.S. Naval forces.

Dr. Kenneth A. Loparo is Nord Professor of Engineering in the Electrical Engineering and Computer Science Department at Case Western Reserve University. His research interests include stability and control of nonlinear and stochastic systems with applications to large-scale electric power systems; nonlinear filtering with applications to monitoring, fault detection, diagnosis and reconfigurable control; information theory aspects of stochastic and quantized systems with applications to adaptive and dual control and the design of digital control systems; the development of advanced signal processing techniques for monitoring and tracking of physiological behavior.

Mr. John Dodson is a licensed professional engineer and graduate of both the U.S. Military Academy and the Harvard Business School. With a partner he founded Thayer Gate Energy, LLC, a non-profit formed to develop the MuniGrid, a surety microgrid based on wind, solar, biomass and fuel cells, utility size storage, and an intelligent energy management system. In the mid-1990s, under the Public Utilities Regulatory Policies Act, he constructed a small hydroelectric plant on a tributary of the Hudson River; he still owns and operates that plant today, selling power into the grid now for over 16 years.